U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION, THOMAS F. HUNT, DIRECTOR; CHARLES F. SHAW, IN CHARGE SOIL SURVEY.

RECONNOISSANCE SOIL SURVEY OF THE CENTRAL SOUTHERN AREA, CALIFORNIA.

BY

J. E. DUNN, IN CHARGE, L. C. HOLMES AND A. T. STRAHORN, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND J. E. GUERNSEY OF THE UNIVERSITY OF CALIFORNIA.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1917.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., July 20, 1920.

SIR: During the field season of 1917 a reconnoissance soil survey was made of the Central Southern California area. This work was done in cooperation with the University of California Agricultural Experiment Station.

I have the honor to transmit herewith the manuscript report and map covering this area and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1917, as provided by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. E. T. MEREDITH,
Secretary of Agriculture.

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RECONNOISSANCE SOIL SURVEY OF THE CENTRAL SOUTHERN AREA, CALIFORNIA.

By J. E. DUNN, In Charge, L. C. HOLMES, and A. T. STRAHORN of the U. S. Department of Agriculture; and J. E. GUERNSEY, of the University of California.—Area Inspected by MACY H. LAPHAM.

DESCRIPTION OF THE AREA.

The Central Southern California area includes nearly all of Orange County, the southern two-thirds of Los Angeles County, the southwestern part of San Bernardino County, and the western part of Riverside County. It is embraced within parallels 33° 30′ and 34° 30′ north latitude and meridians 116° 30′ and 118° 30′ west longitude, and the boundaries are right lines except in the southwest, from Santa Monica to Aliso Point, where the area abuts upon the Pacific Ocean. The southern boundary is approximately 65 miles north of the California-Mexico line. The extent of the area surveyed is 7,330 square miles or 4,691,200 acres.[1] The survey comprises nearly all the developed agricultural sections in these counties.[2]

FIG. 1.—Sketch map showing location of the Central Southern area, California.

PHYSIOGRAPHY AND TOPOGRAPHY.

The area consists of three physiographic divisions: (1) The rough, dissected mountain ranges with the included local valley basins; (2) the desert region, with its long, gently sloping alluvial fans, its characteristic playas in the axial belt of the desert valleys, and its bare, stony, isolated hills and mountain ranges; (3) the valley region, comprising the larger structural basins, with associated stream valleys, low-lying hills, plains, and mesas.

The mountain region.—The surface features of the greater proportion of the area are very irregular and probably over one-half of it is mountainous or hilly. Parts of the San Gabriel, San Bernardino, San Jacinto, and Santa Ana Mountains are included. (See Pl. I, figs. 1 and 2.) As a whole the mountains are rough and broken,

[1] The survey coincides with Southern California Sheet No. 1 of the U. S. Geological Survey, which is compiled from twenty-three large-scale topographic sheets of this region. These large-scale atlas sheets were used as a base map in the soil-survey work.

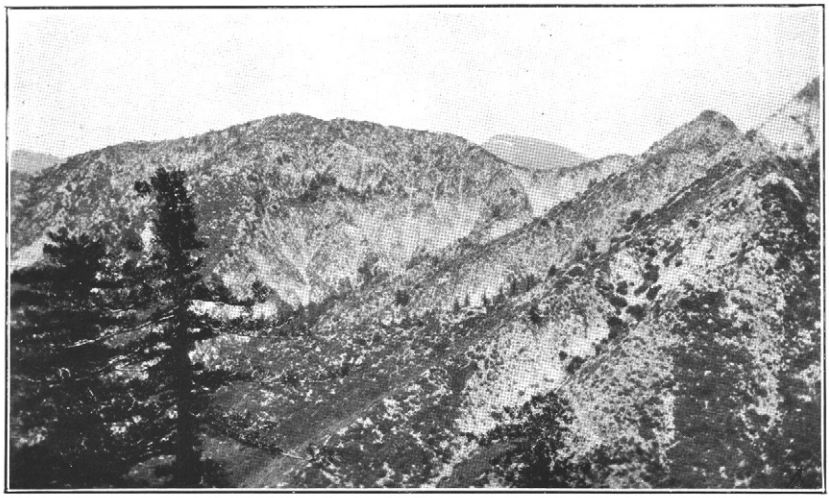
[2] Detailed surveys have been made of parts of this area. Reports on these have been published under the following titles: Soil Survey of the Riverside Area, 1915; Pasadena Area, 1915; Los Angeles County, 1915; Anaheim Area, 1916; and San Fernando Area, 1915. The area also is joined upon the south in part by a reconnoissance survey, a report on which is published under the title Reconnoissance Soil Survey of the San Diego Region, Calif., 1915.

the most rugged mountainous section in southern California lying within the survey. The lands in this division are mainly nonagricultural. Most of the included slopes are extremely steep and very stony, and there are many sharp ridges and bare granite peaks, with intervening V-shaped canyons. These surface features contrast strongly with those of the highly developed agricultural valley region. The elevation ranges from 2,000 to over 11,000 feet.

For the most part the mountains are covered with brush, consisting mainly of various species of ceanothus, scrub oak, Engelmann oak, chemisal, mountain mahogany, laurel, sage, and manzanita, but some yellow pine, Jeffrey pine, sugar pine, cedar, bigcone spruce, and fir occurs along the summits and ravines at the higher elevations, while oak, box elder, cottonwood, alder, and sycamore grow along the streams at lower elevations. The San Gabriel, San Bernardino, San Jacinto, and Santa Ana Mountains form the greater part of the mountainous region. Practically all these are included within National Forests. Besides these major mountain ranges there are a number of less elevated mountain ranges, ridges, and knobs. The more conspicuous of these are the Verdugo Mountains, the Santa Monica Mountains, the San Pedro Hills, the San Rafael Hills, the Puente Hills, the San Jose Hills, the San Joaquin Hills, the Jurupa Mountains, the Badlands, the Box Springs Mountains, and the Lakeview Mountains. Some of these are quite closely associated with the principal mountain ranges already described, but many of them are more intimately identified with the valley regions of the survey and will be referred to more in detail under discussion of that region.

The desert region.—The desert region comprises most of the northern and part of the extreme eastern sections of the survey. It includes parts of the Mohave and the Coachella Deserts and consists of extensive plains formed mainly of sloping alluvial fans extending from the base of the mountains. Numerous playas occur east of the Mohave River. These are slight depressions into which drainage flows. They contain water for a brief period each year and are entirely devoid of vegetation. A few isolated barren mountains lying along the northern boundary are pronounced physical features of this division. Practically all of the region excepting the Coachella Desert lies more than 2,900 feet above sea level. A typical desert vegetation exists. A comparatively small acreage is used for agriculture. Parts of the Mohave Desert east of the Mohave River, known as Apple, Lucerne, and Johnson Valleys, have been settled to some extent.

The valley region.—The valley region includes that portion of the survey, exclusive of the Santa Ana Mountains, lying west of the San Jacinto Range and south of the San Bernardino and the San



S. 9298

FIG. 1.—VIEW FROM MOUNT LOWE TRAIL, IN SAN GABRIEL MOUNTAINS, SHOWING SHARP RUGGED CRESTS AND ROUGH TOPOGRAPHY.

As a whole this is probably the roughest and most broken of the ranges of southern California.

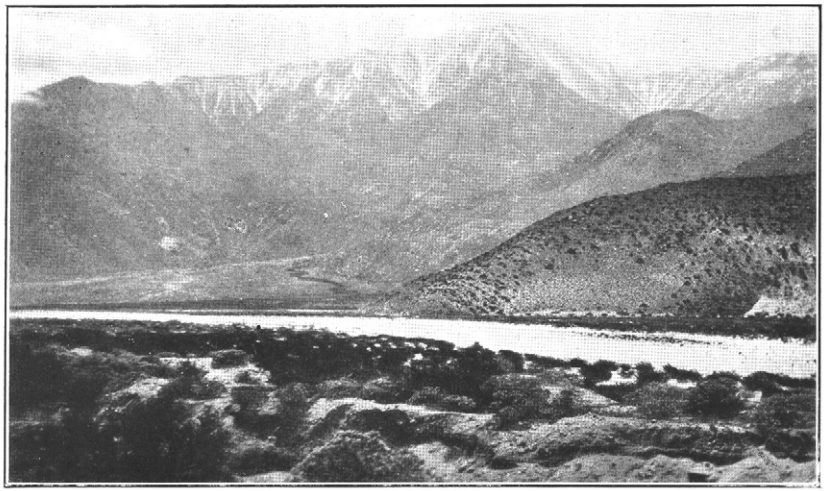


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FIG. 2.—MOUNT SAN JACINTO, FROM SAN GORGONIO PASS, SHOWING ALLUVIAL FAN AT FOOT OF MOUNTAIN, OCCUPIED BY STONY SOILS OF THE TUJUNGA SERIES.

The light-colored strip in the foreground consists of riverwash.

Gabriel Mountains. This region has been defined as the Valley of California.[3]

It consists of a lowland area of associated but more or less distinct structural basins and valleys with marginal plains of alluvial fan formation and numerous groups of included low hills and mountains, the more important of which have already been enumerated. The various segments or parts of the valley region are described briefly in the following paragraphs:

South of Corona, Riverside, Colton, and Redlands, and between the Santa Ana and the San Jacinto Mountains, is a region comprising a number of small valleys separated more or less by groups of low hills and mountains or isloated rocky knobs or peaks. The valleys range in elevation from approximately 1,000 feet to about 1,600 feet and the associated hills and mountains from about 1,200 to 2,800 feet. The larger of the valleys in this region are Perris, Alessandro, and San Jacinto Valleys.

The Perris Valley lies in the northern central part of this region and extends from a point about 4 miles south of Perris northward to the vicinity of Alessandro, a distance of some 12 miles. Its outlines are irregular and indefinite. It is bounded upon the east by the Lakeview Mountains and a number of isolated granite knobs which attain maximum elevations slightly in excess of 2,600 feet and separate the valley from the San Jacinto Valley. The elevation of the Perris Valley at Perris is 1,456 feet and in its northern part slightly more. The surface is nearly level to slightly undulating or rolling. There is but little native tree growth.

Upon the north the Perris Valley expands into the Alessandro Valley. This is in physiographic character similar to the Perris Valley. Like the Perris Valley it is bounded upon the east by an area of irregular hills, mainly granitic, that extends to the north and west. The Box Springs Mountains separate the Alessandro Valley from the Riverside Basin lying on the north at an elevation several hundred feet lower. The Box Springs Mountains, like the Lakeview Mountains, are steep and rocky, and nearly devoid of vegetation. Upon the east the Alessandro Valley extends to the Badlands, which separate it from the San Timoteo Canyon and the Beaumont district. The Badlands consist of an elongated north and south belt of minutely and deeply dissected hills, lying just east of the Beaumont-Banning belt, formed by the erosion of consolidated and unconsolidated sedimentary rocks. The elevation of the Alessandro Valley at Box Springs, near its northern extremity, is 1,539 feet, and at Moreno, in its eastern part, 1,600 feet.

[3] See Hydrology of San Bernardino Valley, California. By Walter C. Mendenhall. U. S. Geological Survey Water Supply and Irrigation Paper, No. 142.

The San Jacinto Valley consists of a lowland basin, mainly structural in origin, extending from Vallevista in a northwesterly direction to the vicinity of Moreno, where it opens out into the Alessandro Valley. The San Jacinto River, following the lowest portion of the basin, flows to the southwest in the vicinity of Lakeview, where this part of the valley joins with the Perris Valley. The southern part of the San Jacinto Valley, where it attains its maximum width and importance, is locally known as the Hemet Valley. The elevation of the San Jacinto Valley at Vallevista is 1,765 feet, and at Lakeview 1,468 feet. The upper or southern part of the valley is well drained and constitutes an important agricultural section, but its lower part is flat and much of it poorly drained and subject to overflow. Its boundary upon the east and north is formed by the Badlands and by the northern part of the San Jacinto Mountains and is marked by a prominent fault line along which recent uplift has taken place.

The southwestern part of the valley region is also marked by a narrow and more or less continuous rift valley extending in a northwesterly and southeasterly direction and parallel to the San Jacinto Valley. Its central part is occupied by Elsinore Lake, its northern part by the valley of Temescal Wash. Its southern part drains to the southeast by Murrieta Creek to the Temecula River. It is bounded upon the west and south by the abrupt slopes of the Santa Ana and Elsinore Mountains.

The central southern part of this region lying south of the Perris Valley and between Elsinore Lake and the San Jacinto Valley is occupied by a number of small poorly defined valleys. Among these are the Menifee Valley, Paloma Valley, Los Alamos Valley, French Valley, Domenigoni Valley, and Diamond Valley. The most of these are similar in topography, occupying flat or basinlike areas. Many of them have imperfectly developed drainage and no permanent streams. There is but little native tree growth.

North of the southeastern part of the survey just described is the San Bernardino-Riverside region. This is sometimes referred to as the San Bernardino Valley. It consists of several parts. The southern part, lying south of the Jurupa Mountains and extending southwestward from the vicinity of Highgrove, is known as the Riverside Basin. The surface of this is generally smooth and gently sloping, being formed mainly by alluvial fan deposits from the Jurupa and the Box Springs Mountains and from the area of hills upon the south. It ranges in elevation from about 800 to slightly more than 1,000 feet above the sea.

The eastern part of the San Bernardino-Riverside region is formed by the San Bernardino Basin. Its alluvial fan deposits are more

pronounced than in the Riverside Basin, and its slopes are longer, as well as steep, and some of them are stony. This is true particularly of the Mill Creek fan, which with the Lytle Creek fan and the wide area of stony alluvium of the Santa Ana River occupying a slightly lower elevation, dominate the recent alluvial deposits. The upper slopes of these stream-built fans have a fall of 150 to 200 feet to the mile. The eastern part of the basin is inclosed upon the east and south by the San Bernardino Mountains, the Crafton Hills, and by the Badlands. About its margins are included some areas of well-defined mesa lands or remnants of older higher lying alluvial plains with smoothly sloping to eroded and dissected surfaces, differing markedly in this respect from the lower lying recent alluvial plains. These mesa areas are especially prominent in the vicinities of Highlands and Redlands. The greater part of this basin ranges in elevation from 1,000 to 1,500 feet, though the lowest parts are slightly less than 1,000 feet and the higher fan slopes and marginal areas attain an elevation of 2,000 feet or slightly more. Upon the west it extends to the vicinity of the Jurupa Mountains. Its upper or northern part, however, extends to the west as a smooth plain, which slopes southward to the Santa Ana River and Chino Creek and gradually merges on the north with the steep alluvial fans along the base of the San Gabriel and the San Bernardino Mountains. This plain continues westward to San Dimas and Lordsburg. It is known as the Cucamonga Plain and ranges in elevation from about 500 to 2,000 feet. Its lower southwestern part is known also as the Chino Plain.

To the west of the Cucamonga Plain are the Puente and San Jose Hills, which constrict the plain to a width of but a few miles and separate it from the San Gabriel Valley or Basin to the west. The Puente Hills are really a continuation of the Santa Ana Mountains and extend in a northerly direction from the Santa Ana Canyon to the valley of San Jose Creek just west of Pomona, and westward to the "Narrows" or the Paso de Bartolo where they are interrupted by the narrow valley of the San Gabriel River and the Rio Hondo a few miles northwest of Whittier. They are formed mainly of sedimentary rocks and as a whole they include much Rough broken and stony land. Most of their slopes are too steep for cultivation, but some are smooth. In places they are covered with brush, with some tree growth along the ravines and on northern slopes. They attain elevations from 800 to 1,200 or 1,500 feet, with San Juan Hill near the Santa Ana Canyon reaching a maximum elevation of 1,780 feet. The San Jose Hills, whose greatest elevation is 1,380 feet, extend from Puente in a general northeasterly direction to San Dimas and Lordsburg. The San Jose and Puente Hills are very similar in character. They are sepa-

rated by the narrow valley of San Jose Creek. They support a fairly good cover of native grasses and where not suitable for cultivation are of considerable value for grazing.

The San Gabriel Valley or Basin, like the region to the east, has been partly filled with stream deposited material, derived mainly from the San Gabriel Mountains. The country consists of numerous coalescing alluvial fans emerging from the mountain canyons and forming a continuous alluvial plain. Some of the fans are young and have a smooth surface, others are older and higher lying and have an eroded surface. The average elevation of this basin is several hundred feet lower than that of the region to the east with which it is connected by the low passes at Lordsburg on the north of the San Jose Hills, and at Spadra just west of Pomona. The elevation at Lordsburg is 1,039 feet, at Glendora and Azusa along its northern margin 765 feet and 614 feet, respectively, at Covina near its central part 555 feet, and at Shorb near its western margin 464 feet. It has a distinct slope to the south and west and is well drained. It is bounded on the south by the San Jose Hills and the northwesterly extension of the Puente Hills, and on the west and southwest by the Los Angeles and the San Rafael Hills.

The Los Angeles Hills, a lower continuation of the Puente Hills, form a connecting ridge between the latter and the eastern part of the Santa Monica Mountains. They are generally of smooth contour and the land is used in the production of dry farmed grain and grain hay, for pasture, and for building sites. They attain maximum elevations of 800 to slightly more than 900 feet.

The San Rafael Hills consist of a somewhat more elevated group of hills lying west of Pasadena. They are formed mainly of granitic rocks, and are rough, stony, brush-covered, and nonagricultural. They are separated from the San Gabriel Mountains on the north by a narrow mountain valley, known as the La Canada Valley, a northwesterly extension of the San Gabriel Valley, and on the west from the Verdugo Mountains by Verdugo Canyon. This is a short but higher and still more rugged range of granitic mountains, in character much like the San Gabriel Mountains.

West of the San Rafael Hills and occupying another basin bounded upon the south by the Santa Monica Mountains, and upon the east and north by the Verdugo and the San Gabriel Mountains is included the eastern part of the San Fernando Valley. The portion of this valley included within the survey consists mainly of smooth alluvial fan plains, sloping south and southeast and ranging in elevation from about 500 feet in its lower southeastern part to about 1,500 feet along its elevated northern margin.

The Santa Monica Mountains and the Los Angeles and the Puente Hills form the northern and northeastern boundary of the Coastal

Plain which covers the western coastal part of the valley region. The eastern boundary of this plain in its southern part is formed by the Santa Ana Mountains and it is bounded on the south by the San Joaquin Hills, a low range composed of sedimentary rocks, extending from the Santa Ana Mountains westward to the Pacific Ocean. These hills are traversed by frequent canyonlike valleys, but many of the slopes are smooth and are used for farming or grazing.

The Coastal Plain is a smooth broad plain sloping gently in a southwesterly direction toward the ocean. Between Long Beach and Playa del Rey the smoothness of this plain is broken by a series of mesas representing remnants of a similar but older and higher lying plain. There is also a narrow strip of undulating sand dunes along the coast from Playa del Rey southward to the north end of the San Pedro Hills. West of Wilmington and San Pedro, the San Pedro Hills, almost 1,500 feet in elevation, stand out in strong contrast to the plain extending to the north and east.

The greater part of this plain between Los Angeles and Wilmington and eastward to the vicinity of Whittier, Yorba, and Santa Ana consists of the lower flat alluvial fan or alluvial delta deposits of the Los Angeles, San Gabriel, and Santa Ana Rivers. The elevation of this plain ranges from practically sea level to 150 to 200 feet above. The elevation at Los Angeles is 294 feet. Areas of eroded remnants of older waterlaid deposits occur as flat topped to rolling mesa lands about its margin, some of which may be of marine origin. The lower and flatter portions of the plain are poorly drained.

There are in the area surveyed other small outlying valley areas, some of which are of considerable agricultural importance. Prominent among these are the Yucaipe Valley and the Beaumont-Banning district. The Yucaipe Valley is an elevated valley lying south of the Crafton Hills, occupying areas of high, well-drained alluvial fans and mountain foot slopes. The Beaumont-Banning district, of recent agricultural development, lies west of San Gorgonio Pass and occupies an elevated, well-drained intermountain valley. The climate of these higher valleys is too severe to permit of the growing of citrus fruits but they have quite recently come into prominence in the production of apples and other deciduous fruits.

DRAINAGE.

The drainage of the region embraced within the survey is mainly to the Pacific Ocean, through the Santa Clara, Los Angeles, San Gabriel, Santa Ana, and San Jacinto Rivers. North of the summits of the San Gabriel and San Bernardino Mountains and east of the summits of the latter named range and the San Jacinto group, the drainage is into the desert regions. The drainage from the northern slope is mainly carried by the Mohave River. Whitewater River

and Mission and Morongo Creeks are the principal streams draining into the Coachella Desert.

In the mountainous region the streams have many tributaries and are usually deeply entrenched in V-shaped canyons of steep gradients. When they reach the valley floors and basins, the slopes of the stream beds diminish, the velocity is checked, and the deposition of immense quantities of sand, bowlders, gravel, and silt begins. Here the stream channels usually widen and become shallow and overflow during flood times. Where the larger streams approach the ocean and the base level has been reached, the streams constantly shift their channels during flood periods and cause much damage to the farm lands in these localities by overflow and sedimentation. In portions of this region southwest of Santa Ana, Anaheim, and La Mirada, the water table is quite high and drainage poorly established. Areas, previously noted, along the San Jacinto River between San Jacinto and Perris, and along the Santa Ana southwest of San Bernardino are also inadequately served by the existing drainage systems. The principal streams of the area have a continuous flow in the mountains but are intermittent after reaching the valleys.

POPULATION AND TOWNS.

According to the United States Census of 1910, the four counties, viz, Los Angeles, Orange, Riverside, and San Bernardino, which are partly or wholly included within the survey, had a total population of 629,969. During the decade 1900 to 1910 the population increased 167 per cent, and in the last eight years there has been further marked increase.

A large percentage of the population live in the cities and incorporated towns. In 1910 Los Angeles alone had a population of 319,198 and 20 other towns within the survey had a population exceeding 2,500. The rural population is probably much less than 50 per cent of the total for the four counties.

The most thickly settled part of the survey is in the valley region extending west from the vicinities of Redlands and Riverside to the ocean. The population of the desert region is sparse and there is little permanent settlement in the mountains. The settlers come from all parts of the United States. About 14 per cent of the population is foreign, mainly Mexican, German, Japanese, and Chinese.

Los Angeles, the principal city of the whole Southwest as well as one of the most important on the Pacific coast, with a population of 319,198 in 1910, is located in the western part of the area on the Los Angeles River. It is an important railroad and commercial center and is widely known as a tourist city. It is the county seat of Los Angeles County. Pasadena, the next largest city within the area, with a population of 30,291 in 1910, situated

only a short distance northeast of Los Angeles, is an attractive residential city and noted for its tourist hotels. Riverside, San Bernardino, Redlands, Pomona, Ontario, and Claremont are important cities in the central part of the survey ranging in population in 1910 up to 15,000. They are located in a highly developed agricultural region and are prosperous and progressive. Riverside is the county seat of Riverside County and is a very popular tourist city, while San Bernardino is the county seat of San Bernardino County and is quite an important shipping center. The shops of the Atchison, Topeka & Santa Fe Railroad are located at the latter place.

Elsinore, Perris, Hemet, and San Jacinto are located in the region between the San Jacinto and the Santa Ana Mountains and are the distributing points and market centers for the valleys of that section. San Fernando, Lankershim, Van Nuys, and Burbank are important local points in the San Fernando Valley. Long Beach with a population in 1910 of 17,809, is the largest city on the coast between Santa Barbara and San Diego. It is an important residential and tourist city. Santa Monica, Venice, Redondo, Huntington Beach, Newport Beach, and Laguna Beach are important resort and residence points along the ocean. Some of these are also fishing and shipping points of considerable local importance. Wilmington and San Pedro, now included within the city limits of Los Angeles, are the principal ports.

TRANSPORTATION.

The transportation facilities for the developed agricultural section of the survey are exceptionally good. Los Angeles is the terminus of three trunk line railroads, besides being the center of an extensive electric railroad system. The region is connected with the east by the Atchison, Topeka & Santa Fe, the Los Angeles & Salt Lake, and the Southern Pacific Railroads, which furnish good service in the transcontinental transportation of fruits and other agricultural products to the eastern markets. The connection to San Francisco and the north is by the Atchison, Topeka & Santa Fe and the two lines of the Southern Pacific. Los Angeles is also connected with San Diego on the south by a branch of the Atchison, Topeka & Santa Fe Railroad. Various spurs and branches of these railway systems reach to practically every shipping point and town of importance within the survey. An extensive network of electrically operated lines of the Pacific Electric Railroad also furnish frequent passenger and freight service between all the important points of the coastal district and of the interior valleys as far east as Riverside, Redlands, and San Bernardino.

The developed region has exceptionally good wagon roads. Practically all of the towns are connected with first-class highways and

these, with good cross or secondary roads, permit the easy marketing of farm products during any part of the year. Practically all the travel on the roads is by motor vehicles. Motor trucks carry the greater part of the farm products to market, as well as much of the freight and merchandise which was previously carried by the railroads, while motor stages operate between all the cities and towns of importance. Automobile stage service is also maintained between Los Angeles and San Diego, Bakersfield, Fresno, San Francisco, and other important places outside the survey.

The farmers in the developed agricultural sections have telephones, rural free delivery, and in many cases electric light and power.

MARKETS.

Los Angeles and the other cities and towns within the area consume practically all the dairy and meat products, poultry, berries, hay, and large quantities of the garden products. The citrus fruits, walnuts, dried and canned fruits, beans, olives, wines, and some of the truck crops are shipped to various parts of the country. Sugar beets are grown to supply sugar factories located at Santa Ana, Anaheim, Huntington Beach, Los Alamitos, and Chino.

CLIMATE.

As in the greater part of the State, the climate of the area is characterized by a wet and a dry season coinciding generally with winter and summer. In detail the climatic conditions vary widely in the different parts of the area; indeed this is one of the striking features of the region. This variation is due chiefly to differences in elevation, the position of the mountain ranges, and the influence of the ocean.

The wet season usually extends from the first of November to the latter part of April and is followed by a long period during which there is very little precipitation and few cloudy days. At Los Angeles, according to records of the United States Weather Bureau, there are 157 clear days, 152 partly cloudy days, and 56 cloudy days in the average year. The average number of days on which some rain falls is 36. At Palm Springs, in the extreme eastern part of the survey, on the desert, the average number of days with some precipitation is 10.

The rainfall varies greatly in different parts of the area. It is greatest in the mountainous regions and least on the desert. Bear Valley, in the San Bernardino Mountains, has a normal annual precipitation of over 30 inches, while Palm Springs, in the Coachella Desert, has but a trifle over 4 inches, and in 1903, the driest year recorded, there was but seven-tenths of an inch of rain at this point.

Los Angeles, in the valley region, has slightly less than 16 inches. With certain minor exceptions the rainfall gradually decreases from the coast to the east until the mountains are reached, when it increases with increase in elevation, the maximum occurring along the summits of the higher mountain ranges, where a considerable proportion of it occurs as snow. Snow becomes deep during the winter and remains on the higher peaks until late in the summer.

The storms are usually general, and cloudy weather and high winds often prevail on the desert when rain occurs in the valley and mountainous regions. The rains are frequently of several days' duration, usually gentle, and accompanied with little wind. Hail, thunderstorms, and cloudbursts are of rare occurrence in the valley region, but are more frequent in the mountains and desert. Excepting the driest portions of the desert, the rainfall is sufficient to allow the growing of certain crops throughout the area in many of the soil types without irrigation.

During the wet seasons the relative humidity of the atmosphere is comparatively high, with the maximum occurring along the coast. It gradually decreases from the coast toward the interior and is lowest in the desert. The annual mean relative humidity of Los Angeles for a period of 24 years is 71. During the late winter, spring, and summer months morning fogs are frequent, being heaviest along the coast. During the dry season a low humidity prevails.

In the tables given at the end of this chapter will be found statistics of precipitation for different stations selected to show the conditions in parts of the area. Of these Barstow, whose records are representative of the Mohave Desert region, is located about 40 miles northeast of Hesperia. The Lowe Observatory is situated on the slopes of Mount Lowe in the San Gabriel Range about 5 miles northeast of Pasadena at an elevation of 3,420 feet. Bear Valley Dam lies at the western end of Bear Lake in the San Bernardino Mountains at an elevation of 6,500 feet. Idyllwild, for which snowfall records are also given, is a mountain resort in Strawberry Valley on the southwestern slope of Mount San Jacinto at an elevation of 5,250 feet.

The temperature, like the precipitation, varies widely from place to place and has a marked influence on the type of agriculture and the distribution of crops of the region. The most uniform temperatures occur along the coast where the weather is always cool and subject to little daily and seasonal changes on account of the modifying influence of the ocean. Toward the interior of the valley region where the ocean winds gradually lose their tempering effect, the temperatures are subject to much greater range and oftentimes

during the summer days becomes quite hot, though the nights are usually cool. In the mountains from the lower foothill slopes to the summits, the temperature has a wide range which is principally due to the change in elevation. In the higher mountainous regions, the winters are cold, while the night temperatures in the summer are comparatively low and will allow the growth of only the most hardy crops. This is illustrated in the temperature records at Idyllwild, where temperatures of 32° or less have been recorded during every month of the year with the exception of August.

In the desert the summer day temperatures are frequently extremely high. Most of the Mohave Desert included within the survey lies, however, near the mountains and at considerable elevation, and owing to rapid radiation the nights are usually cool. Barstow, the only point in the Mohave Desert for which data are available, lies at an elevation of 2,150 feet and from 700 to 1,000 feet or more below the lower parts of the desert included within this survey. During the winter it is often quite cold and disagreeable, with temperatures reaching almost to zero. The temperature records at Palm Springs, in the Coachella Desert, at an elevation of 584 feet, show mean monthly and annual temperatures which are considerably higher, and winter temperatures much less severe.

High winds are frequent on the desert, generally occurring during the day and becoming quiet at night. In the valley region the winds are mostly from the west and southwest, with occasional periods of extremely hot winds during the summer from the north. The latter usually last one to three days, and on account of the excessive heat are very disagreeable and severely affect vegetation. In various places trees are planted for windbreaks to protect orchards.

Frosts often cause considerable damage in Southern California. They occur most frequently in the lower valley basins and in other depressed areas where the cold air accumulates during the night. The slightly higher slopes, mesas, and alluvial fans, with good air drainage, are much freer from frost and form a thermal, or comparatively frostless, belt where citrus fruits are grown. However, in places even these areas are subject to frost and facilities for orchard heating are used in various places during periods of danger. Frost data for the various localities are given in the accompanying table.

Normal monthly, seasonal, and annual temperature and precipitation.

Month.	Idyllwild.						Palm Springs.			
	Temperature.		Precipitation.				Temperature.	Precipitation.		
	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1905).	Snow, average depth.	Mean.	Mean.	Total amount for the driest year (1903).	Total amount for the wettest year (1905).
	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
December	73	11	2.27	0.10	1.93	3.96	55.2	.96	0.00	0.00
January	71	6	5.33	5.20	6.85	13.07	56	.70	.00	2.16
February	73	6	4.65	.60	8.43	10.47	58	.88	.00	3.95
Winter	73	6	12.25	5.90	17.21	27.50	56.4	2.54	.00	6.11
March	77	11	6.60	3.08	10.07	8.08	64.6	.59	.70	1.66
April	91	15	1.86	.33	2.21	2.54	72.4	.04	.00	T.
May	96	24	1.18	.00	3.77	T.	78	.03	.00	.48
Spring	96	11	9.64	3.41	16.05	10.62	71.7	.66	.70	2.14
June	93	28	.06	.00	.00	.00	87.7	T.	.00	.00
July	99	32	.50	.55	.03	.00	94.5	.02	.00	.00
August	98	33	1.29	.21	.17	.00	91.4	.20	.00	.00
Summer	99	28	1.85	.76	.20	.00	91.2	.22	.00	.00
September	91	28	.65	.15	.38	.00	84.6	.09	.00	.00
October	87	22	.92	1.43	T.	.45	75.2	.20	.00	.00
November	81	10	2.16	2.40	8.38	4.98	64.4	.30	.00	1.11
Fall	91	10	3.73	3.98	8.76	5.43	74.7	.59	.00	1.11
Year	99	6	27.47	14.05	42.22	43.55	73.5	4.01	.70	9.36

Month.	Barstow.[1]						San Jacinto.[2]					
	Temperature.			Precipitation.			Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1904).	Total amount for the wettest year (1905).
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*
December	46.8	87	14	0.60	T.	0.70	50.3	89	20	1.49	1.02	0.22
January	47.8	80	18	.62	T.	3.39	49.9	90	21	2.74	.32	3.46
February	51.7	84	18	.49	0.30	.45	51.9	91	19	2.03	1.15	6.48
Winter	48.8	87	14	1.71	.30	4.54	50.7	91	19	6.26	2.49	10.16
March	57.8	94	21	.56	.10	.20	54.1	102	26	2.76	3.02	4.89
April	62.2	99	30	.07	.00	.44	58.6	101	27	.82	.35	1.03
May	67.8	111	34	.04	.00	.22	63.6	109	32	.47	.15	1.26
Spring	62.6	111	21	.67	.10	.86	58.8	109	26	4.05	3.52	7.18
June	77.4	110	40	.00	.00	.00	71.2	112	37	.00	.00	.00
July	83.4	114	50	.12	.40	1.35	80.7	111	44	.09	.00	.00
August	83.4	112	48	.15	T.	.00	76.1	109	43	.22	.32	.37
Summer	81.4	114	40	.27	.40	1.35	76.0	112	37	.31	.32	.37
September	74.3	111	39	.16	.00	.10	71.0	110	38	.18	.00	.00
October	64.0	97	27	.51	.00	.27	63.8	103	30	.77	.13	.24
November	54.9	90	14	.30	.00	.00	56.4	99	24	1.08	.00	2.54
Fall	64.4	111	14	.97	.00	.37	63.7	110	24	2.03	.13	2.78
Year	64.2	114	14	3.62	.80	7.12	61.9	112	19	12.65	6.46	20.45

[1] Killing frost: Latest in spring, Feb. 26; earliest in fall, Oct. 24.
[2] Killing frost: Average last in spring, Mar. 17; average first in fall, Nov. 22; latest in spring, Apr. 8; earliest in fall, Oct. 22.

Month.	Elsinore.[1]						San Bernardino.[2]					
	Temperature.			Precipitation.			Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1898.)	Total amount for the wettest year (1906).	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1881).	Total amount for the wettest year (1884).
	°F.	°F.	°F.	Inches.	Inches.	Inches.	°F.	°F.	°F.	Inches.	Inches.	Inches.
December	51.7	90	19	1.77	1.38	5.51	52.4	88	19	2.57	0.50	3.75
January	50.3	90	18	3.07	2.29	2.78	51.5	87	18	3.33	1.40	1.63
February	52.9	95	20	2.37	.15	2.14	53.7	90	22	2.99	.36	12.20
Winter	51.6	95	18	7.21	3.82	10.43	52.5	90	18	8.89	2.26	17.58
March	55.6	103	24	3.04	.82	11.98	55.5	97	26	2.91	1.66	9.95
April	60.4	109	26	.44	.23	1.59	59.8	103	29	1.17	.46	5.68
May	64.6	109	31	.33	1.32	1.46	63.7	108	33	.60	.01	3.17
Spring	60.2	109	24	3.81	2.37	15.03	59.7	108	26	4.68	2.13	18.80
June	71.2	113	35	.03	.01	.08	69.8	112	37	.08	.00	.59
July	78.0	114	45	.02	.00	.00	75.6	111	42	.04	.00	.00
August	77.4	115	42	.21	.00	.03	75.7	111	42	.15	.00	.00
Summer	75.5	115	35	.26	.01	.11	73.7	112	37	.27	.00	.59
September	73.0	114	36	.16	.00	.19	71.1	111	38	.14	.00	.00
October	65.2	109	28	.52	.00	.07	64.2	105	31	.60	.80	.00
November	57.4	96	22	1.24	.04	1.34	57.4	99	24	1.39	.27	.11
Fall	65.2	114	22	1.92	.04	1.60	64.2	111	24	2.13	1.07	.11
Year	63.1	115	18	13.20	6.24	27.17	62.5	112	18	15.97	5.46	37.08

[1] Killing frost: Average last in spring, Mar. 17; average first in fall, Nov. 16; latest in spring, May 9; earliest in fall, Oct. 21.

[2] Killing frost: Average last in spring, Mar. 14; average first in fall, Nov. 18; latest in spring, Apr. 15; earliest in fall, Oct. 23.

Month.	Riverside.[1]						Corona.					
	Temperature.			Precipitation.			Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1898).	Total amount for the wettest year (1884).	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	°F.	°F.	°F.	Inches.	Inches.	Inches.
December	53.4	88	21	1.57	1.38	2.56	49.6	79	28	3.71	2.98	4.46
January	51.1	87	24	2.01	1.74	.84	50.6	83	30	10.22	5.21	17.12
February	52.7	91	24	1.98	.12	7.94	54.0	82	31	3.69	5.37	1.59
Winter	52.4	91	21	5.56	3.24	11.34	51.4	83	28	17.62	13.56	23.17
March	55.9	102	25	2.34	.80	6.56	59.4	95	32	1.09	.91	1.56
April	60.4	104	31	.68	.18	1.67	61.0	98	37	.89	1.86	.02
May	65.2	103	33	.35	.27	1.99	61.9	100	35	.38	.89	.07
Spring	60.5	104	25	3.37	1.25	10.22	60.8	100	32	2.36	3.66	1.65
June	70.6	107	40	.05	.00	.52	69.1	105	42	.15	T.	.00
July	76.3	110	44	.02	.00	.00	72.6	110	48	.003	.00	.00
August	76.4	111	44	.14	.00	3.00	73.7	107	47	.09	.27	T.
Summer	74.4	111	40	.21	.00	3.52	71.8	110	42	.243	.27	T.
September	72.1	112	40	.14	.00	.00	70.7	101	46	.18	.00	.55
October	62.2	103	31	.54	.00	.12	63.8	100	35	.63	.00	1.11
November	58.2	95	27	.77	.01	.12	59.6	93	33	.56	1.12	.11
Fall	64.2	112	27	1.45	.01	.24	64.7	101	33	1.37	1.12	1.77
Year	63.0	112	21	10.59	4.50	25.32	62.2	110	28	21.593	18.61	26.59

[1] Killing frost: Average last in spring, Feb. 15; average first in fall, Dec. 16; latest in spring, Apr. 2; earliest in fall, Nov. 11.

Month.	Los Angeles.[1]						Bear Valley Dam.			Lowe Observatory.		
	Temperature.			Precipitation.			Precipitation.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1898).	Total amount for the wettest year (1884).	Mean.	Total amount for the driest year (1896).	Total amount for the wettest year (1916).	Mean.	Total amount for the driest year (1898).	Total amount for the wettest year (1909).
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	55.3	89	30	3.98	0.12	4.64	3.76	2.00	7.38	2.14	0.98	18.98
January	53.1	87	30	2.93	1.26	3.15	6.35	2.26	37.60	5.50	1.55	14.22
February	54.1	88	28	3.27	.51	13.37	4.86	.61	3.88	5.01	2.22	11.94
Winter	54.2	89	28	10.18	1.89	21.16	14.97	4.87	48.86	12.65	4.75	45.14
March	55.6	99	31	2.98	.98	12.36	8.70	2.96	7.55	5.97	1.65	7.38
April	57.6	100	36	1.36	.03	3.58	1.62	.98	.73	1.40	2.70	.56
May	60.5	103	40	0.43	1.75	.35	1.77	.48	.58	1.82	2.17	.03
Spring	57.9	103	31	4.77	2.76	16.29	12.09	4.42	8.86	9.19	6.52	1.37
June	64.5	105	46	.10	T.	1.39	.20	.00	.00	.28	.00	.75
July	67.4	109	49	.02	.07	T.	.16	.15	.23	.01	.00	.00
August	68.6	106	49	.03	T.	T.	.77	.41	.55	.13	.00	.00
Summer	66.8	109	46	.15	.07	1.39	1.13	.56	.78	.42	.00	.75
September	66.5	108	44	.06	.02	T.	.46	.10	1.66	.37	.25	.15
October	62.3	102	40	.74	.09	.39	1.41	1.90	5.07	1.62	.30	1.40
November	58.4	96	34	1.38	T.	1.06	2.59	1.60	.42	2.24	.00	3.10
Fall	62.4	108	34	2.18	.11	1.45	4.46	3.60	7.15	4.23	.55	4.65
Year	60.3	109	28	17.28	4.83	40.29	32.65	13.45	65.65	26.49	11.82	58.51

[1] Killing frost: Latest in spring, Jan. 27; earliest in fall, Dec. 23.

AGRICULTURE.

Southern California was first explored in 1542 by Cabrillo, but very little further exploration or settlement was attempted until 1769, when the Franciscans began the establishment of their missions for the purpose of Christianizing the native Indians and developing the uncolonized country. The Indians were encouraged in the practice of agriculture, and the setting out of olives, tree fruits, and vineyards, and the planting of field and garden crops was begun at an early date, considerable quantities of grain being produced. Land was also utilized for pasturing thousands of cattle, horses, sheep, and hogs, which gradually increased in number as the missions grew older.

During the early period the Spanish and Mexican Governments also made many land grants to private individuals. These grants, called "Ranchos," were very large, some of them comprising thousands of acres, and included practically all of the attractive and best located portions of Southern California. At first they were used almost exclusively for grazing, but when markets began to develop, large acreages adapted to crop production were planted to grain. As agriculture developed a greater demand arose for farm lands, and this gradually caused the disintegration of the large tracts and their sale as smaller individual farms to homeseekers.

The early agriculture was seriously handicapped on account of the lack of markets. Occasionally hides and tallow and probably wine and grain were exported to Mexico and South America, but the volume of such trade was small. Practically the sole demand was local, to supply home consumption. As a result the herds on the range increased until there were thousands of cattle, horses, and hogs for which there was no demand and which were of little value. Many of the cattle were killed for the hides alone. This situation was somewhat relieved by the discovery of gold in 1848. During the few following years the population of the State, and consequently the demand for farm products, increased very rapidly. The acreage of grain was increased, more meats were used, and the condition of agriculture as a whole was much improved.

However, the market and transportation problem continued serious until the building of the Southern Pacific and the Atchison, Topeka & Santa Fe Railroads in 1874 and 1885, respectively. After this many settlers came, the development of the vineyard and fruit industries began, the "ranchos" were subdivided into smaller units, and the region as a whole began a rapid development which has continued until the present time. On account of the good transportation facilities, the supply of water available for irrigation, a climate favorable to the production of a great variety of crops, and the

occurrence of large bodies of fertile soils, the area has come to include one of the most highly developed and productive agricultural regions within the United States.

The citrus-fruits industry produces a large annual income while many of the deciduous fruits, grapes, walnuts, and the general field and truck crops occupy large acreages throughout the area. Some attention is also given to the dairy and live-stock industries and to the production of poultry, eggs, and honey.

The following data for Los Angeles, Orange, Riverside, and San Bernardino Counties from the United States census reports for 1910 gives a general idea of agricultural conditions at that time.

Farm statistics [1] *for 1909, for Los Angeles, Orange, Riverside, and San Bernardino Counties.*

	Los Angeles.	Orange.	Riverside.	San Bernardino.
Number of farms	7,919	3,165	2,688	2,949
Land in farms, acres	2,602,880	508,800	4,633,600	12,900,480
Number of farms operated by owners	5,599	2,531	2,291	2,532
Number of farms operated by tenants	1,968	506	293	183
Number of farms operated by managers	352	128	104	234
Number of farms with mortgage debt	1,889	957	816	961
Average acres per farm	95.7	117.4	193.8	70.7
Average improved acres per farm	52.9	59.9	103.5	46.3
Total number of cattle	43,095	18,220	19,468	12,761
Total number of horses and mules	24,994	12,833	11,744	7,656
Total number of sheep and goats	39,329	44,101	7,933	88
Total number of hogs	28,942	4,448	6,150	3,749
Receipts from sale of dairy products, dollars	1,362,257	241,741	215,747	123,555
Value of honey and wax, dollars	93,569	18,525	62,337	23,466
Total value of all crops, dollars	14,720,884	6,176,337	5,133,576	6,818,233
Total value of fruits and nuts, dollars	6,731,532	2,497,734	2,393,371	5,357,098
Total acres in cereals	49,957	32,415	73,236	5,932
Alfalfa, acres	19,027	5,304	12,904	8,263
Grain, cut green, acres	129,978	35,753	73,985	33,764

[1] U. S. Census, 1910.

The more important phases of agricultural industry are discussed under their respective heads in the following pages:

Citrus fruits.—Among the more important products of the area are oranges and lemons. According to the report of the State Commission of Horticulture for 1915, the total acreage of orange groves in Los Angeles, Orange, Riverside, and San Bernardino Counties was 109,037 acres, with 77 per cent in bearing, and of lemons was 23,100 acres, with 51.4 per cent in bearing. The 1910 United States Census reports give the total production of oranges and lemons in the four counties as 14,518,046 boxes.

The industry as a whole is confined largely to the gentle slopes and alluvial fans between the base of the mountains and the lower

and flatter valley floors. It is confined mainly to districts that are well drained and relatively free from frosts. Many orchards, however, on account of their unfavorable location, are subject to frosts which sometimes cause serious damage. Loss from this cause has been minimized by orchard heating, but this is very expensive to install and operate, and consequently the cost of production in the affected groves is considerably greater than in the more favorably situated groves. The lemon is considered more sensitive to frost than the orange.

The production of citrus fruits is not confined to any particular type of soil, but is found on residual, recent alluvial, and old valley-filling soils belonging to a number of different series and varying in texture from a stony or gravelly sandy loam to a clay loam or clay. The better lemon groves appear to be on the lighter textured types of soil, while a large number of the better orange groves are on soils of medium texture. The light-textured types require more water for irrigation and need heavier fertilization than the soils of heavier texture, but efficient cultivation of the heavy types is much more difficult.

Fertilization is necessary in the culture of the citrus fruits. Cover crops and barnyard manure are used extensively with good results, but large quantities of commercial fertilizers are also used. Cover crops are grown during the winter and are plowed under in the early spring. Throughout the remainder of the year clean cultivation is usually practiced, though in some cases a mulch of straw or similar material is substituted for a soil mulch, having the same effect—checking evaporation and preventing the growth of weeds. While the trees are young, a tilled crop is often grown between the rows. All of the citrus groves are irrigated. The amount of water necessary for irrigation and the number of irrigations needed during a season varies considerably, depending largely on the texture of the soil, the character of the subsoil, the age of the grove, the winds, and the annual rainfall and its distribution. From 5 to 8 good irrigations are usually necessary during the year.

The two principal varieties of oranges grown are the Washington Navel and the Valencia, and of lemons the Eureka and Lisbon. The orange groves begin bearing when they are about 4 years old and continue to increase their yields until they are 12 to 18 years of age. The Navels and Valencias give about the same yields. According to the records of the Citrus Protective League, the average yield of oranges, taking a five-year period as a basis, is 157.6 packed boxes per acre. The yields of individual orange groves, however, vary widely depending upon the soil, the location, the effectiveness of irrigation, and the quantity of fertilizer used. The winter crop con-

sisting of Navels, is picked between December and May, inclusive, and the summer crop, Valencias, from May to August, inclusive. The lemons, like the oranges, vary widely in yield. For a five-year period the average, according to the Citrus Protective League, was 196.2 packed boxes per acre.

The grapefruit is of relatively little commercial importance, and has received less attention in the development and propagation of improved varieties or strains. It is grown to a small extent in a few localities, and reported to be profitable under favorable conditions. The production of this fruit gives promise of further development.

Walnuts.—The walnut industry is important in Orange and Los Angeles Counties, but in Riverside and San Bernardino Counties walnuts are grown only in a small way. According to the Report of the State Commission of Horticulture for 1915, there were 33,099 acres in walnut groves in the four counties, with 66.3 per cent of the area in bearing. Over seven-eighths of this total acreage was in Los Angeles and Orange Counties. The production as given by the United States Census in 1910 was 13,728,256 pounds.

The walnut is not so susceptible to frost as the orange and lemon and is usually grown on the lower lying lands nearer the valley floor and below the citrus belt. The most extensive centers have developed in the coastal district in the vicinities of Santa Ana, Orange, Anaheim, Fullerton, and Whittier, the equable temperature and relatively high humidity of the coast section being favorable to walnut production. In the Hemet Valley relatively small but locally important plantings have been made. A considerable acreage also occurs in the San Gabriel Valley and in the valley of San Jose Creek, as well as in the region around Chino and Pomona.

The greater proportion of the walnut orchards are on the well-drained recent alluvial soils of the Hanford and Yolo series. A small acreage has been planted on the soils of the Ramona and Placentia series, derived from old valley-filling material. The Hanford soils are prevailingly light, mostly sandy loams and fine sandy loams. The texture of the Yolo soils is somewhat heavier, ranging from a sandy loam to a clay loam.

Ordinarily walnuts are not heavily fertilized, but both barnyard manure and commercial fertilizers are used to a small extent, and where an ample supply of water for irrigation is available cover crops occasionally are grown and plowed under.

In general the bearing orchards are given clean cultivation. However, when the trees are young, truck crops, grain, berries, and sometimes alfalfa, may be grown between the rows, and it is also a common practice to set quick-maturing fruit trees, such as peaches and apricots, as fillers, to be removed when the walnuts come into bearing.

The greater part of the area in walnuts is irrigated. The quantity of water and the number of irrigations necessary can not be stated definitely, as so much depends upon the type of soil and the location of the orchard. Many of the growers make from three to five or occasionally six applications of water each season, in the period from April to August, inclusive.

The principal varieties of walnuts are the Placentia, Eureka, Prolific, and El Monte. The walnut matures slowly and yields very little until it is 7 or 8 years old. The average yield for trees 10 years old is reported to be about 850 pounds per acre. The crop is harvested from October to December.

Grapes.—The growing of grapes was introduced in the early days by the missions. The industry continued to increase in importance until about 1880 or 1890. About this time the production of orchard fruits began to develop rapidly, and many of the vineyards were removed to make room for fruits offering larger profits. Nevertheless, the production from the vineyards in Los Angeles, Orange, Riverside, and San Bernardino Counties in 1910 was large, being, according to the United States census, 98,272,814 pounds.

Scattered vineyards occur throughout the valley region, but the industry is centered in the region lying south of the San Bernardino Mountains and between Rialto and Ontario, and to parts of the San Fernando Valley included within this survey.

Grapes are grown mostly on the extremely light textured soils of the Hanford and Tujunga series. The largest vineyard in the area, covering some 4,000 acres near Guasti, is growing very successfully on types of sand. This soil, however, has a rather compact, slightly heavier subsoil, which, considering its light texture, is very retentive of moisture.

The vineyards receive no fertilization and are not irrigated, except in a very few places where table and raisin grapes are grown in small quantities. The vineyards are plowed in the early spring and given clean cultivation during the rest of the season.

Several varieties of grapes are grown, practically all for making wine. The vines begin yielding when about 3 years old and continue in bearing for many years. The yields range from 2 to 5 tons per acre.

Deciduous fruits.—The growing of deciduous fruits is an important industry in certain sections of the survey. The following table gives a general idea of the distribution and importance of various crops in this general group. The data are taken from the report of the State commission of horticulture for 1915.

Area and distribution of deciduous fruits, 1915.

County.	Peaches.		Apricots.		Apples.		Pears.	
	Total area.	Area in bearing.	Total area.	Area in bearing.	Total area.	Area in bearing.	Total area.	Area in bearing.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Los Angeles	6,536	2,922	1,913	1,472	1,577	927	2,699	311
Orange	1,050	50	1,760	1,600	380	150	.....	.....
Riverside	2,894	1,837	6,011	2,688	3,339	817	948	310
San Bernardino	9,415	6,703	2,482	1,652	1,258	7,808	434	115
Total for 4 counties	19,895	11,512	12,166	7,412	6,554	9,702	4,081	736

The principal peach centers are in the section southeast and northeast of Ontario, comprising approximately 6,000 acres, and in the Hemet Valley, comprising 1,500 acres, with 700 acres in bearing, and in the southeastern part of the San Fernando Valley. A small acreage is also producing in the Banning region, and in the San Gabriel and Yucaipe Valleys, while a few scattering orchards are found throughout the valley region.

In general, peaches are grown principally on the light-textured soils of the Hanford and Tujunga series. (Pl. II, fig. 1.) In the Ontario district the soil is a light loose sand which is shifted more or less by the wind. The subsoil, while a sand in texture, is rather compact, carrying more fine material than the surface soil, and is retentive of moisture. In the Hemet Valley the soils are heavier in texture, consisting mostly of sandy and fine sandy loams, while in the San Fernando Valley the peach soils range in texture from a sand to fine sandy loam or light loam. Throughout the remainder of the area the orchards are planted on soils that have a rather wide textural range.

The peaches in the Ontario region receive little or no irrigation, grow vigorously, and yield from 2 to 5 tons per acre. Cover crops are not usually grown, and no fertilizers are used, except in some orchards, where small quantities of barnyard manure are placed around the base of the trees. The cost of production in this section is quite low.

In the Hemet Valley practically all of the orchards are irrigated. Very few of the owners grow cover crops, but where barnyard manure is obtainable it is sometimes used for fertilizer. Winter cover crops can not be grown even where the rainfall is sufficient, on account of cold weather, while during the irrigating season it is not considered profitable, as considerable water is necessary for their growth. The trees in this section are very thrifty and produce fruit of excellent quality, with an average yield for the whole valley of about 4 tons per acre.

The principal varieties of peaches are the Tuskena, Phillips Cling, Orange Clingstone, Lovell, Elberta, and Muir. The greater proportion of the fruit is canned, but relatively small quantities are used fresh or dried for local use. Canneries are located at Hemet, Ontario, and in the San Fernando Valley.

Apricots are grown in the same general localities as peaches. In the Ontario district the acreage is much less than that of peaches, while in the Hemet Valley the acreage is much greater. In the Hemet Valley there are about 4,000 acres in apricots, one-half of the orchards being in bearing. In the San Fernando Valley the acreages in peaches and apricots are probably about equal. A number of apricot orchards are located around Banning also. Orange County, producing but few peaches, has about 1,600 acres of apricots, practically all in bearing. It is reported that considerable difficulty has been encountered here on account of diseases which, with the more or less unfavorable local climatic conditions, has caused low yields and failure in many of the orchards. Apricots are grown on the same soils as peaches and receive about the same general treatment as the latter fruit in the several regions.

Only a small proportion of the area is well adapted to the growing of apples and pears, and except in a few sections they have been grown principally for local use. The Yucaipe Valley, comprising about 5,000 acres of deciduous fruits, mostly apples, is the most important district. Most of the orchards here, however, are young, only three to seven years old. A considerable acreage of apples is also located around Beaumont and Banning and along Cajon Canyon north of Devore. Practically all of these orchards are irrigated but not fertilized. The orchards are almost entirely on the sandy loam and loam of the Ramona and Placentia series. The trees show vigorous growth, and the producing orchards yield fruit of good quality. On the desert a few tracts of apples and pears have been planted in Apple Valley, east of the Mohave River, and in Lucerne Valley, northeast of Rabbit Springs. A few scattering orchards also occur on the higher desert slopes near the base of the mountains west of Cajon Pass. Around Valyermo and west of Rock Creek there also are a few small plantings of pears. The greater proportion of the orchards on the desert have been planted on soils derived from old valley-filling material. All of them, except a few of small extent near the base of the mountains, are irrigated.

At various places throughout the valley region apples have been planted for home use, but on account of unfavorable climatic conditions such plantings have not been successful.

The principal varieties of apples grown are the Winesap, Rome Beauty, Delicious, Jonathan, Bellflower, Winter Banana, King David, and Pearmain.

Olives.—Olives have been grown more or less extensively since their introduction into the region in the early days of mission settlement. Until the last few years it has been the common practice to grow them without irrigation and with very little cultivation, and as the varieties were usually poor, very inferior fruit was produced and low yields usually obtained. At the present time many of the older orchards have been replanted with new varieties, and with irrigation and better cultural methods greatly increased yields have resulted and the industry has become much more profitable.

Olives are grown throughout the valley region, the most extensive acreage being located northeast of San Fernando. Another center of considerable importance occurs south and east of Declez, while 370 acres of irrigated olive groves are reported in the Hemet Valley. In many places the olives have been planted as a border tree.

The largest orchards are on the light-textured soils of the Tujunga and Hanford series, while the small isolated orchards and border trees occur on a wide variety of soils. The principal varieties are the Mission, Nevadillo, and Manzanillo.

Beans.—Beans are a very important crop in the western part of the valley region, where climatic conditions are especially favorable for their production. Localities that are warm but not subjected to high temperatures, and where fogs are frequent and a rather high humidity prevails are well adapted to the growth of lima beans, which is the important bean crop in this area. While a few scattered tracts of the Blackeye, Pink, and Tepary varieties are grown in the interior valleys the greater portion of the bean crop in this survey is confined to the section south and west of the Santa Monica Mountains and the Puente Hills, and west of the Santa Ana Mountains. Here extensive acreages are planted annually.

The soils used for growing beans are usually well drained and free from alkali, and range widely in texture from a sand to clay adobe. The lighter textured soils, as compared with the heavy types, are more easily cultivated and the bean crop matures earlier and is less likely to suffer damage from the fall rains. They, however, give lower yields than the heavy textured soils. Large tracts are frequently planted to beans continuously for many years without any apparent decrease in the yield, but on some of the lighter textured soils beans are rotated with grain crops. It is the common practice to grow beans without irrigation or fertilization. They are usually planted in May after the last spring rains, in a well-prepared seed bed, and then cultivated two to three times during the growing season. They usually mature the latter part of August or in September, when they are cut and thrashed.

Sugar beets.—Sugar beets are quite tolerant to alkali, and produce fair yields on soils that have considerable concentrations. Conse-

quently the greater part of the sugar beet acreage has been confined to the poorly drained lands, carrying more or less alkali, which are not suitable for the production of fruits or other intensively cultivated crops. Between 2,000 and 3,000 acres are grown in the vicinity of Chino, a still larger acreage between the fruit belt and the ocean in the region extending from the Santa Monica Mountains to the San Joaquin Hills, and important plantings in the San Fernando Valley.

The beets are grown largely on the Hanford, Chino, Tujunga, and Yolo soils of various textures, with the greater part of the crop probably produced on the fine sandy and silt loams. A lower tonnage is obtained from the lighter textured soils, but the sugar content is usually higher. The yields in some of the low, wet regions have been greatly improved by artificial drainage. Except in these poorly drained places, the crop is usually irrigated about twice during the season. Barnyard manure is used in a limited way on a few of the fields, but as a whole very little fertilization is done. It is also customary in many places to grow beets with very little crop rotation.

Beets are planted from the 1st of January until the middle of May, the time of seeding depending on the season. The plants are thinned four to five weeks after planting, cultivated and hoed several times, and harvested in the fall from September until into November. The yield averages about 8½ tons per acre, with the sugar content from 17 to 19 per cent.

Truck and berry crops.—The large number of cities and thickly settled communities in the area provide an extensive local market for truck and berry crops. The demands of this market, combined with the eastern demand for winter and early spring products, has caused a large area to be devoted to this type of farming. The principal commercial trucking centers are largely confined to the western part of the survey, in the vicinities of Los Angeles, Ramona, San Pedro, and Long Beach. Considerable quantities in less extensive areas are also grown near other of the numerous towns as well as scattered through certain portions of the fruit belt. Within a radius of 25 miles of Los Angeles probably 15,000 acres are utilized for truck growing.

Truck crops are grown on many kinds of soils, comprising recent alluvial, residual, and old valley filling types ranging in texture from sand to clay adobe.

Strawberries are a very important crop, with the largest acreage occurring in the vicinity of Gardena and Moneta. They are produced, with good yields, mainly on the Montezuma clay adobe, but to some extent on lighter textured soils of the Ramona and the Oakley series. The principal varieties are the Klondike and the Brandywine. Blackberries, raspberries, and loganberries also are grown for local markets.

Lettuce, tomatoes, cauliflower, cucumbers, and cabbage are grown extensively for local and eastern markets, while large acreages of sweet corn, potatoes, peas, string beans, and other vegetables are grown for local use. In many of the areas the crops are grown without irrigation and without fertilizers; in others the crops are irrigated and heavily manured. The methods employed depend largely on the crop, the location, and the soil on which it is grown. Most of the corn and potatoes are produced on the light textured soils of the Hanford, Tujunga, and the Oakley series. Practically all of the large truck farms are operated by the Japanese, who are very efficient in this industry.

Grain and grain hay.—While extensive areas of the survey are devoted to highly specialized crops, large acreages are also used for the production of grain and grain hay, which are grown more or less throughout the area and on many different kinds of soils. The yields fluctuate widely with the seasons, the crops being dry farmed. They are produced mostly on the residual soils and on areas of the valley floors and slopes that can not be economically irrigated. Barley, wheat, and oats, of importance in the order named, are grown. The greater part of the acreage is cut before maturity for hay. It is fed by the grower or sold in the local markets.

Grain is sown in the early winter months, after the first rains, which come in the late fall, and is cut in May and June following. Much of the land used for the production of grain is cropped continuously. A few rotate grain or grain hay with other crops, such as sugar beets and beans, and others follow the system of summer fallowing. Besides barley, wheat, and oats Egyptian corn and various of the grain sorghums are grown to some extent. None of the grain is irrigated and no fertilizers are used.

Alfalfa.—Alfalfa is a crop of considerable importance. It is grown on various soils throughout the valley region where water is available for irrigation and usually where local climatic conditions prohibit the growing of fruits. A small acreage is also established in the Mohave Desert in the Lucerne Valley and in the vicinity of Rock Creek, as well as on the recent alluvial soils along the Mohave River. The largest yields are obtained on recent alluvial soils of light or medium texture. There is a considerable production on land that is poorly drained and contains small quantities of alkali, but the yields on such areas are low and the stand is usually thin or of short life.

All the alfalfa is irrigated and in the valley region from 5 to 7 cuttings are obtained, with yields from about three-fourths to 1½ tons per cutting. In the desert only 3 to 5 cuttings are obtained, with about the same yields per cutting as in the valley region.

In the fruit belt alfalfa is sometimes grown as a cover crop and turned under as a green manure. A considerable proportion of the crop is grown by dairymen and stockmen, who feed it to cattle and hogs. The rest of the production is sold in the local markets.

Dairying.—Dairying is confined largely to the alfalfa districts and the lower valley lands adjacent to the cities, the most important development being in the vicinity of Los Angeles. Soils unsuitable for fruit production are used. The mild climate and the excellent local markets make dairying in this section especially attractive. Most of the dairy farms are large and usually have good equipment and first class herds. According to the United States 1910 census the gross income from the sale of all dairy products in the entire area was $1,943,300.

Live stock.—Notwithstanding the fact that there is a large local demand for horses, cattle, and hogs, the production of live stock is not now an important industry. Hogs are raised in considerable numbers in the grain and alfalfa districts, but considering the size of the area the production is small, and probably the greater part of the income from the sale of stock comes from cattle. A few large cattle ranches are still found in the area, and some smaller stock farms are scattered throughout the region. The cattlemen use the mountainous and the rough broken hills for grazing. Few horses or mules are raised for sale in the area.

Poultry and eggs.—On account of the large and increasing demand of the cities and thickly settled rural communities for poultry and eggs, the industry has developed into one of considerable importance. The raising of poultry is scattered throughout the entire area and in the desert it is the principal source of income for the homesteaders. Upon many of the farms devoted to fruits or other intensively cultivated crops, the owner of which may live in one of the adjacent cities or towns, no poultry products are produced. Many, however, who live on their land carry poultry as an adjunct to their regular farming operations, and there are a few who devote their entire time to the industry. Many of those owning young citrus groves depend upon the poultry business as a considerable source of income until their trees come into bearing.

Many different breeds of chickens, the important poultry class, are found in a community, but the White Leghorn is apparently the favorite breed. The receipts from the sale of poultry and eggs in 1910, for the counties included within the survey, was $1,215,830.

Miscellaneous.—In 1910, 2,830,607 pounds of honey was produced in Los Angeles, Orange, Riverside, and San Bernardino Counties. The apiaries are scattered throughout the area. The honey produced is of excellent quality.

A specialty has been made in a few places in growing nursery stock, garden seeds, flowers, and flower seeds.

Eucalyptus has been planted and grown successfully in the valley region for windbreaks and for wood.

Numerous kinds of fruits, such as figs, plums, prunes, loquats, avocados, and cherries are grown to a small extent in various places throughout the fruit belt. Cherries and prunes are locally important and profitable in the vicinities of Beaumont and Banning. A few almonds are produced, but they are a minor crop.

In the highly developed specialized farming districts the machinery and equipment of the farms is modern and sufficient; in the desert homesteads and in the mountains, where the yearly returns from agriculture are small, the equipment is poor. In the valley region, especially in the beet, bean, and some of the grain-growing sections, farm tractors are used extensively and very successfully in preparing and planting the land to crops.

According to the United States census of 1910, 1,607 farms in Los Angeles County, 426 in Orange, 706 in Riverside, and 1,624 in San Bernardino reported the use of fertilizers. A total amount of $1,772,354 was spent for their purchase in these counties in that year. The use of fertilizers with the various crops has already been stated in the discussion of those crops.

Farm labor is usually obtained without serious difficulty. Much of the labor on the small farms is performed by the owners. Mexicans are usually employed in the sugar-beet fields, and Chinese and Japanese gardeners grow much of the truck crops.

A few exceptionally large ranches are located within the area, but the tendency has been to subdivide the large tracts with the increase in settlement, until now many of the individual holdings in the intensively farmed fruit sections consist of 5 and 10 acre tracts. Many of the orange and walnut groves are from 10 to 20 acres in size; the orchards of the deciduous fruits are usually somewhat larger. The alfalfa ranches vary in size. The farms devoted to grain, sugar beets, and beans are probably the largest. Most of the farms on the desert consist of 160 acres or more. The majority of the fruit orchards and walnut and citrus groves are operated by the owners, but much of the land used for the growing of beets, beans, and truck crops is leased.

The land values for the area included within this survey have an extremely wide range varying from that of the highly developed citrus orchards which often sell for $2,000 or more per acre to the land that is practically worthless for agricultural or grazing purposes. In this region many factors enter into the determination of land values and the selling price. Some of the most important of these are local conditions of climate, particularly with regard to rainfall and occurrence of frosts, character of the soil and its relation to crop productivity; the location with respect to cities, resorts, and high-

ways; alkali, and drainage; available water supply for irrigation and its cost if obtainable; and the general improvements, including the kind and general condition of trees if planted to fruit. These various factors cause wide variations in values of land adapted to the growing of the same crops, and any statement of farm values must be very general. It is quite common for bearing walnut orchards to sell for $1,000 an acre, and the majority of the citrus groves in bearing bring from $1,000 to $2,000 an acre. In the Hemet Valley good bearing apricot orchards with water rights sell for $500 to $700 per acre, while in the Yucaipe Valley and in the vicinity of Beaumont four to nine year old apple orchards are selling from $400 to $800 per acre. Land adapted to alfalfa and sugar beets is held at $150 to $500 an acre and well located grain farms in the older and better developed parts of the survey, with no available water for irrigation, range in price from about $50 to $100 an acre.

The land on the desert, where it is impossible to obtain water for irrigation, is sold with difficulty, and then at a very low figure, but the well irrigated farms are held at about two-thirds of the selling price for similar lands in the valley regions.

SOILS.

The soils of the Central Southern California area vary greatly with the variation of the climatic conditions prevailing in the different parts of the area under the influence of which the various soils have been developed.

In parts of the area the rainfall is very low, and in parts high, the amount varying in general with the elevation above sea level and also with the exposure. In the regions of high or at least of considerable rainfall, where the total annual precipitation amounts to 25 inches or more, the maturely developed soils assume the characteristics of humid soils with low humus content and correspondingly light color, with brown to reddish, fully oxidized, and aerated subsoils thoroughly leached of all easily soluble mineral salts, including the carbonates, and usually with subsoils somewhat heavier in texture than the soils. The soils of the Sierra and Holland series, the lighter-textured members of the Altamont series, and apparently those of the Pleasanton, Placentia, and the lighter-textured members of the Ramona series have these characteristics. There is some reason for questioning the justification of placing the soils of the last three series mentioned in this group, as at the time the survey was made a careful study of this relationship was not made, and their characteristics resemble in some respects those of the very old soils of the more arid areas.

In the lower parts of the area, in some of the intermountain valleys shut off from the coast winds by mountain ranges, and in the Mohave

Desert the soils have developed under conditions of very low rainfall and have assumed the characteristics of arid soils. They are all light in color and all the older members have well-developed hardpans, either calcareous or ferruginous, while all the younger members are calcareous in the surface soil or the upper subsoil. The subsoils may vary from gray to reddish, assuming the latter color in the older soils, such as those of the Mohave or San Joaquin series. The members of this group of soils include the various types of the Mohave, Hesperia, Madera, San Joaquin, and Cajon series, although the Cajon soils are new alluvial accumulations derived from the other series mentioned.

Very few soils of the area show well-developed semiarid characteristics. This is probably due to the fact that there are no large areas of table-lands lying at considerable elevations, where the rainfall is intermediate between that of the lowlands and the desert on the one hand and that of the high mountain areas on the other. There are two or three series of soils which seem to possess the characteristics of soils developed under semiarid conditions well enough defined to warrant placing them in this group. They have dark-colored surface soils, brown or reddish upper subsoils, and lower subsoils varying considerably in color.

The surface and upper subsoils have been well enough leached to have been deprived of carbonates, while the lower subsoil and the upper substratum contain accumulations of lime carbonate. The various members of the Antioch series as mapped in this area seem to belong in this group of soils, and the loam, clay loam, and clay of the Altamont series have the characteristics just described fairly well developed.

Soils of another group which do not partake of the character of any of the groups already described are present in this area in considerable quantities. Though they approach those of the last-mentioned group, they differ from them in that they have more lime carbonate in the subsoil. The carbonate lies nearer the surface and its presence seems to be due to the character of the parent rock rather than to the result of climatic influences. The various types of the Diablo, Dublin, and Montezuma soils seem to belong in this group.

There are a number of soils within the area that have accumulated in basins and valleys and contain varying amounts of alkali. These are the members of the Chino, Las Flores, Foster, and Lahontan series. They vary in color, texture, and other characteristics rather widely, but all carry a small percentage of accumulated salts.

Another group includes alluvial accumulations entirely or practically free from the presence of alkali salts. These are alluvial deposits, derived largely from the humid soils of the uplands, with

some contributions from soils of the other groups. They include some of the most productive soils of the area. The various members of the Hanford, Tujunga, and Yolo series belong in this group.

The descriptions of the individual soil units of the area are arranged according to the source of the material from which the soils have been developed and the processes by which that material was accumulated where the soils are now found. A discussion of the soils of the area from this point of view follows:

CLASSIFICATION.

Southern California is a region of structural valleys and mountain ranges. It has been subjected to severe and long continued erosion which has reduced the higher elevations and built up the basic floors and flood plains with deep sedimentary deposits. At various times during this wearing down and building up process it has undergone changes and alterations in the relative elevation of its various parts by crustal movements and fractures of the earth surface. More or less folding and metamorphism in the rocks has taken place and some of the mountainous areas with the filled-in valleys have been elevated and eroded into more rugged and rough broken mountain ranges. Other portions have been relatively lowered into regions of depression. These movements are indicated by the occurrence of numerous fault lines and escarpments. At the present time the agencies of erosion are still active in the mountainous regions and the streams are continually moving the weathered and eroded material from the steeper slopes and depositing them at lower levels.

The soil material comes from various kinds of rocks comprising a number of different geological formations. The greater part of the main mountain groups consists of igneous material, mostly granitic, with some gneiss, schist, and volcanic formations; while many of the lower hills and mountains adjacent to the valley region, such as the Santa Monica Mountains, and the Puente, San Jose, and the San Pedro Hills, consist largely or wholly of sedimentary rocks—sandstones, shales, and conglomerates.

The soils of the survey are classified mainly into four groups, based on the process by which the soil material was accumulated, consisting of (*a*) residual soils; (*b*) soils derived from Coastal Plain and old valley-filling material; (*c*) recent alluvial soils; and (*d*) wind deposited soils. The residual soils, if we include Rough broken and stony land, cover the greatest area. They consist of material which has weathered from the consolidated rocks and which has remained approximately in the place where this weathering has occurred. They occupy the mountainous and hilly regions. The Coastal Plain and old valley-filling group is formed from old alluvial or marine deposits which through weathering and leaching have developed more or less distinct soil and subsoil characteristics since they

were laid down. They usually occupy the slopes and plains at elevations below the residual and above the recent alluvial soils. The soils in the recent alluvial group are now in the process of formation. They consist of the fresh material deposited by streams on their present flood plains and fans, and include the largest area of agricultural lands. The wind-laid soils, small in extent, consist of material which has been transported and deposited by winds.

Each of these groups of soil forming materials is represented by one or more soil series. A series includes material having similar characteristics of color, mode of formation, origin, and subsoil features. A series is made up of a number of soil types that differ only in texture, which is determined by the proportion of particles of different sizes making up the soil.

RESIDUAL SOILS.

The residual soils are confined mainly to the lower lying mountains and hills, with occasional patches or areas of small extent in some of the higher mountain sections, usually along the mountain divides or summits, or on the shoulders of ridges or in some of the depressed basins.

As previously stated these soils are derived from the disintegration and weathering in place of the underlying consolidated rocks. The parent rocks, which are of wide diversity, include igneous, metamorphic, and sedimentary formations, and the resulting soils have a wide variation in origin, texture, structure, and depth.

The soils derived from the igneous rocks consisting mainly of granite and gneiss, are grouped in the Sierra and Holland series, and those derived from the sedimentary rocks, consisting of calcareous and silicious shales, sandstones, and conglomerates, are included in the Altamont and Diablo series. The areas of igneous rocks are eroded and the topography is usually quite broken and dissected with more or less rock outcrop. In contrast the soils from sedimentary rocks generally have a smooth surface and though the slopes are in many places steep rock outcrops seldom occur. While the depth of the soils varies greatly, the bedrock in much of the residual area is encountered at less than 6 feet. As a whole, the soils of this division are well or excessively drained, so much so that the areas of shallow depth become quite droughty during the dry season.

Small areas of Rough broken and stony land are included in these soil bodies where the topography is broken and there is considerable rock outcrop.

OLD VALLEY-FILLING AND COASTAL PLAIN SOILS.

The soils of the Old valley-filling and Coastal Plain group are derived from old unconsolidated waterlaid deposits that have been subjected to alteration and modification through weathering since their deposition, as shown by their color, topography, and subsoil

conditions, such as zonal arrangement, compact layers and in some places hardpan. The soils of this division are extensive, notwithstanding the fact that large areas have been eroded away or covered deeply with later alluvial deposits. They occupy remnants of elevated alluvial fans, mesas, and valley plains, generally lying at elevations between the recent alluvial and the residual soils. Their original smooth uniform surface has been changed in many places to undulating and uneven, and in some localities it is deeply trenched by stream channels and young valleys. Eleven series in this division were recognized and mapped in the present survey. These consist of the San Joaquin, Placentia, Ramona, Pleasanton, Madera, Antioch, Las Flores, Montezuma, Mohave, Hesperia, and the Lahontan series.

RECENT ALLUVIAL SOILS.

The recent alluvial soils occupy stream flood plains, low terraces, and the younger alluvial fans. They are composed of material transported from the various drainage basins of the streams, and consequently vary widely. The alluvial soils are not characterized consistently by heavy or compact subsoils, hardpan, or other evidences of weathering or leaching, but by generally permeable subsoils similar to the surface soil or of irregularly variable texture. The topography ranges from steeply sloping in the fans to level in stream bottoms. The surface is generally smooth, but may be modified in places by minor erosions or by drifts. Seven series of recent alluvial soils were mapped in this survey, the Tujunga, Hanford, Cajon, Foster, Chino, Yolo, and Dublin series.

WIND-LAID SOILS.

The soils in this survey which have been laid down by the wind were encountered in the western portion of the area north of the San Pedro Hills, and in the vicinity west of Colton. Only one series, the Oakley, was recognized and it is small in extent when compared with the other soil series.

MISCELLANEOUS MATERIALS.

In addition to the four groups already named, are certain areas mapped as Rough broken and stony land, Coastal beach and dune-sand, Riverwash, and Tidal marsh, all which are of very little value for agriculture. These are placed in a miscellaneous group, for they are not classified on the basis of the criteria used in the preceding four groups, such classification not being necessary owing to their nonagricultural nature.

UNIT OF MAPPING.

In detailed mapping the type is the unit of mapping, but in reconnoissance work, like that of the present survey, either the type or a group of types, depending upon the extent, the complexity of arrangement, and difference or similarity in agricultural value.

In the present survey a few individual soil types were mapped, but two or more soil types were usually combined and shown on the map as a soil group. Twenty-three soil series comprising 47 types or groups of types, including the miscellaneous types, are mapped. The following table gives an outline of the classification and the area of the various soils and soil groups as shown upon the map:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Residual material:			Recent alluvial material:		
Sierra series—			Tujunga series—		
Sierra loam and sandy loam	24,128	0.5	Tujunga stony sands and stony sandy loams	64,000	1.4
Holland series—			Tujunga gravelly sands and gravelly sandy loams	46,144	1.0
Holland sandy loams	111,104	2.4	Tujunga sands	39,808	.8
Holland loam	29,184	.6	Tujunga sandy loams	29,376	.6
Altamont series—			Hanford series—		
Altamont sandy loams	7,744	.2	Hanford sands	107,968	2.3
Altamont loam	39,680	.8	Hanford gravelly and stony sandy loams	102,080	2.2
Altamont clay loam and clays	70,144	1.5	Hanford sandy loams	210,496	4.5
Diablo series—			Hanford fine sandy loam	176,704	3.7
Diablo clay loams and clays	16,064	.3	Hanford loams	40,256	.9
Coastal plain and old valley-filling material:			Hanford clay loams	1,472	.1
San Joaquin series—			Cajon series—		
San Joaquin loam and sandy loam	8,896	.2	Cajon sandy loams	79,232	1.7
Placentia series—			Foster series—		
Placentia sandy loam	37,056	.8	Foster sandy loams and loams	6,016	.1
Placentia loams	50,048	1.1	Chino series—		
Ramona series—			Chino loams	35,712	.8
Ramona stony loams	11,584	.2	Mucky phase	896	
Ramona sandy loams	168,256	3.6	Chino clay loams and clays	46,656	1.0
Ramona loams	166,656	3.5	Yolo series—		
Ramona clay loam	28,480	.6	Yolo sandy loams	31,104	.7
Pleasanton series—			Yolo loams	75,200	1.6
Pleasanton loam	8,512	.2	Yolo clay loams and clays	41,792	.9
Madera series—			Dublin series—		
Madera sandy loams	2,432	.1	Dublin clay loam and clays	14,464	.3
Antioch series—			Wind-laid material:		
Antioch soils, undifferentiated	11,392	.2	Oakley series—		
Las Flores series—			Oakley sands	24,192	.5
Las Flores loam and sandy loams	9,536	.2	Miscellaneous material:		
Montezuma series—			Rough broken and stony land	2,331,840	49.7
Montezuma adobe soils	18,688	.4	Coastal beach and Dunesand	5,440	.1
Mohave series—			Riverwash	28,992	.6
Mohave sandy loam	24,832	.5	Tidal marsh	7,488	.2
Mohave loam and clay loam	24,192	.5	Total	4,691,200	.....
Hesperia series—					
Hesperia stony sandy loam	17,856	.4			
Hesperia sandy loams	236,160	5.0			
Lahontan series—					
Lahontan clay loams and clays	21,248	.5			

SOILS FROM RESIDUAL MATERIAL.

Sierra Series.

The soils of the types included in the Sierra series are light red to deep red, brownish red, or pronounced reddish brown in color, with a tendency to become much redder when wet and browner when dry. They are underlain by subsoils which are usually of heavier texture, more compact structure, and redder in color than the surface soil, and which usually merge into the bed rock at depths ranging from 2 to 6 feet. The soils in many places are gritty and carry small angular to subangular fragments of quartz and feldspar. Considerable areas of rock outcrop or of land with more or less broken topography, rendering them unfit for cultivation, exist. The soils of this series are derived from granitic rocks. As mapped in this survey small areas of Holland and Aiken soils as well as a few patches of old alluvial deposits are included. The soils of the Aiken series are of similar color but are derived from igneous rocks which contain less quartz than the granitic rocks. Owing to their small extent no attempt was made to map them separately. The soils of the Sierra series occupy areas of rolling to steeply sloping topography and are well drained. They are of small extent, occurring mostly in the region south of Riverside. They are mapped in a single group of soils the Sierra loam and sandy loam.

SIERRA LOAM AND SANDY LOAM.

The Sierra loam and sandy loam group except for a few minor variations includes only the two soils named of which the loam predominates.

Description.—The Sierra loam consists of a reddish-brown to red, more or less micaceous, friable loam, low in organic matter. The subsoil, encountered between 12 and 24 inches below the surface, is a compact, gritty, red loam to a clay loam. At depths of less than 6 feet the material passes into a thin layer of partially disintegrated granite which rests upon the unaltered rock. When wet the surface soil has a tendency to be sticky. It is also slightly gritty and in places contains a few small rock fragments, but nowhere sufficient to interfere with cultivation.

The Sierra sandy loam is very similar to the loam in all respects except texture. Only two or three areas of this soil occur.

The group includes, as mapped, a few small areas of Holland material, small bodies of partially reworked soils lying in basins and related to the old valley-filling soils, and patches of red soil derived from basic igneous rocks and properly classed with the Aiken series. The latter lie southwest of Winchester. Small areas of dark-colored residual soils from shales and dark-colored schists also are included here.

Location.—The group has a comparatively small extent and occurs mainly in the vicinity and south of Riverside. The largest areas consisting mainly of the Sierra loam, lie between Arlington Mountain and Box Springs Canyon, and two areas, mainly of sandy loam texture, near the Three Sisters. Small areas lie west and northwest of Riverside in the Jurupa Mountains, on the southern boundary of the survey southwest of Murietta near Mesa de Colorado, and south of the Menifee Valley in the region east of Elsinore.

Topography and drainage.—The soils occupy undulating to rolling or low mountainous regions, with steep slopes in places but on the whole with rather even and smooth surfaces. There is some rock outcrop and the surface also is cut here and there by stream ways and canyons. Drainage is usually good, and on some of the steeper slopes excessive. There is considerable run-off during the rainy season which causes more or less erosion.

Utilization and adaptation.—The soils of this group are of secondary importance and are used mostly for the production of grain, grain hay, and for pasture. Parts of some of the areas still remain in the native state. On the lower slopes of the mountains south of Riverside, oranges, lemons, and other fruits are grown successfully with irrigation, and are apparently well adapted to this purpose. With irrigation truck and general farm crops will succeed, but the cost of water in most places is excessive. At present, very little commercial fertilizer or manure is used, but the addition of organic matter is very beneficial. On account of wide differences in topography, elevation, and convenience of location, the price of land shows much variation, ranging from $40 to $200 an acre.

Holland Series.

The surface soils of the types included in the Holland series range in color from dark brown or brown to slightly reddish brown. The soil sometimes extends to bedrock with little change, but in most places is underlain by a subsoil somewhat redder in color, heavier in texture, and more compact, which passes at a depth of less than 6 feet into partly weathered granitic material and then to solid rock. The soils are derived typically from the granites and similar rocks, but in this survey small bodies of material derived from metamorphosed igneous and volcanic rocks properly belong to the Aiken. The soils occupy areas of rolling or hilly to mountainous topography, with rock outcrop in many places. The soils of this series are mapped in this survey as the Holland sandy loams and the Holland loam.

Holland sandy loams.

The group of soils comprising the Holland sandy loams includes the sandy loam, the coarse sandy loam, the stony sandy loam, and

the fine sandy loam types. Of these the Holland sandy loam is the most important and greatest in extent.

Description.—The soil of the Holland sandy loam is a brown micaceous sandy loam with variations from a slightly reddish brown to a grayish-brown color, low in humus, and containing small angular particles of quartz and granite, which render it more or less gritty. At a depth of from 8 to 20 inches it grades into a heavy gritty sandy loam to loam subsoil of brown to reddish-brown color and in most places very compact, with a tendency to become hard and slightly impervious when dry and sticky when wet. Below this lies a stratum of disintegrated granite which rests on the bedrock at depths frequently less than 6 feet.

The Holland coarse sandy loam is of lighter, coarser texture, contains much more coarse gritty material, and has a looser structure than the sandy loam. The soil is usually grayish brown. Most of the type has a steeper topography, includes more rock outcrop and rough broken areas, and is subject to more erosion than the sandy loam type. The coarse sandy loam is of small extent.

The Holland stony sandy loam is much like the coarse sandy loam except that it contains considerable quantities of rock fragments. Like the coarse sandy loam type it is unimportant in this survey, only one or two bodies being encountered.

The fine sandy loam type is finer and smoother in texture than the sandy loam and the subsoil is not so heavy and compact. In a few places the subsoil is lacking, the soil being uniform in texture to the underlying bedrock. The topography is less rolling and broken and the soil more retentive of moisture than the sandy loam. Only a small area of fine sandy loam exists in this area.

As mapped the group includes unimportant areas of the Aiken and Sierra series and much rough and stony land that would be separated in a detailed survey.

In the southeastern part of the survey soil of decidedly gray color recognized as belonging to the Siskiyou series, which is similar to the Holland series in origin and differs in its lighter gray color, has been included.

Location.—This group includes some of the most extensive and widely distributed soils of residual origin. The largest areas lie in the region between the Santa Ana and the San Jacinto Mountains and southeasterly from Riverside to the boundary of the survey. The more important areas in this locality are west from Perris, Alessandro, and Box Springs station and in the vicinities of the Glenoak, Coahuila, and Terwilliger Valleys. The area west of the Allesandro Valley contains considerable areas of Sierra sandy loam. Several other rather important bodies are located in the vicinity of the Eagle Rock Valley west of Pasadena and small scattered areas

are mapped elsewhere in the survey. Small scattered areas in the mountains are entirely surrounded by Rough broken and stony land and of little agricultural value. The principal area of the stony loam type occurs about 5 miles south of Wildomar.

Topography and drainage.—The topography of this group is moderately to steeply sloping. The areas include some fairly smooth and even land, but in places the surface is broken by rock outcrop and by deeply cut ravines and canyons. Drainage is good, and on some of the steeper slopes the run-off is excessive and erosion active. Over the greater part of the types the soil is absorptive and retentive of moisture.

Utilization and adaptation.—Grain hay and grain, grown without irrigation, are the main crops on the soils of this group. Some grapes and olives are produced also under dry-farming methods. Water for irrigation is available in the vicinity of Riverside and in small areas adjacent to the San Fernando Valley, and oranges, lemons, and deciduous fruits are grown here successfully, though on a small scale. Elsewhere irrigation is impracticable. A part of the area, mostly in the rougher mountainous region, is still covered with a thick growth of brush, a few trees, and a scant growth of grass. This uncleared land is used for grazing.

With the exception of small areas in the rougher mountain sections the areas of this group are fairly accessible to markets. Summer fallowing and the addition of organic matter to the soil where practiced usually increase production.

HOLLAND LOAM.

Description.—The Holland loam is a brown loam with reddish-brown to grayish-brown variations. It is typically smooth to the touch, but in places contains enough small, sharp, quartz particles to give it a gritty feel, though not so gritty as the Holland sandy loams. It also may contain large rock fragments, but rarely in quantities sufficient to interfere with cultivation. It is friable, micaceous, and low in organic matter. At a depth of 10 to 18 inches there occurs a reddish-brown to red heavy compact loam to clay loam. When dry this material becomes very hard and the roots of certain crops have difficulty in penetrating it. As in case of the Holland sandy loams the subsoil is underlain with partially disintegrated rock material and that in turn by the unaltered granite. The depths of soil and subsoil material are extremely variable. In many places rock outcrops are numerous, and on the steep slopes and ridges where erosion has been active the soil material is very shallow. In places where the conditions have been more favorable to accumulation it may be more than 6 feet deep. The type is subject to some variations in texture and color. As mapped it includes small areas of old Aiken material derived from basic volcanic rocks, of the Sierra

and old valley-filling soils, of Rough broken and stony land, of the Holland sandy loams, and of brown soils derived from basic igneous rocks, the last belonging in the Olympic series.

Location.—The Holland loam occurs in scattered areas along the lower slopes of the mountains and is often partly or wholly surrounded by areas of nonagricultural Rough broken and stony land. The largest bodies lie in the low mountainous region south and southwest of Riverside. Smaller but important areas occur west of Pasadena and in the vicinity of La Canada Valley, and several small areas in the low mountainous region south of the Menifee Valley and west of Bachelor Mountain. Some of the areas of Aiken material, which as already stated have been included, occur in the locality of Bachelor Mountain, northwest of Pomona, and in the mountains south of Gavilan Peak.

Topography and drainage.—The topography of the Holland loam consists of steep slopes and rolling or somewhat broken mountains and hills, with moderately even and smooth surfaces in some places, but with eroded and dissected surfaces in many of the areas. Drainage is good and there are no alkali accumulations. On some of the steeper slopes where the run-off is excessive and the soil is shallow the land is droughty. Where the soils have moderate depth they retain moisture quite well.

Utilization and adaptation.—As with the Holland sandy loams, dry-farmed grain and grain hay are the principal crops. The yields are moderate. In a few places where water for irrigation is available, deciduous fruits, oranges, and lemons have been planted and are growing well. Over much of the type water is not available and on account of this the crop range is narrow. The greater part of the type still remains in its native condition, with a dense growth of brush.

Altamont Series.

The soils of the Altamont series are prevailingly brown, ranging from light to dark, with variations that are slightly reddish brown. The subsoil in most areas is lighter in color, heavier in texture, and more compact in structure than the soil. Bedrock in many areas lies less than 6 feet below the surface. The series is derived from sedimentary rocks, principally sandstone and shale. In many places the subsoil contains considerable quantities of lime. The soils of this series occupy moderate to steep slopes in areas of rolling or hilly to mountainous topography. In this survey a few areas also occur on terraces along the ocean. The surface is usually much smoother and less broken than that of the Sierra and Holland soils and rock outcrop is much less abundant. The soils are well drained, but for the most part retentive of moisture. This series is mapped as two groups of types, and one individual type.

ALTAMONT SANDY LOAMS.

Description.—The Altamont sandy loams group includes the sandy loam and the fine sandy loam types of the series. It is of small extent and minor importance in this survey.

The Altamont sandy loam is for the most part brown to slightly grayish brown in color in places, is relatively light in texture, and while varying in depth, normally has a depth of more than 12 inches. It has a loose porous structure and is friable and easily tilled, but is low in organic matter, containing considerably less than the heavier types of the series. The subsoil ordinarily is heavier in texture and more compact than the surface soil, and has a tendency to become hard and to crack where exposed. Also in many places it is lighter in color than the surface soil, not uncommonly having a yellowish tinge. It may contain variable amounts of lime. It is underlain at varying depths by bedrock consisting largely of conglomerates and sandstones.

A number of variations occur in this type. One of the most noticeable consists of gravelly areas that have resulted from the weathering of the conglomerate rock. The soil in these gravelly bodies is more open, retains moisture poorly, and consequently has a lower agricultural value than the typical soil. Also parts of the type on the steep slopes, where erosion has been excessive, are shallow and in many places the subsoil or the bedrock is exposed. These areas on account of their lack of power to absorb and retain moisture and because of their unfavorable topography are also of lower value than the greater part of the group. Near Laguna Beach the type occupies narrow marine terraces between the ocean and the adjacent areas of steep broken topography. The bedrock here was probably worn down by the ocean, later elevated, and subsequently weathered and disintegrated into material which was included with the Altamont series. It is doubtful if some of this material should be correlated with the Altamont, and some of it clearly consists of unconsolidated or partly consolidated coastal plain or alluvial fan deposits, which in a detailed survey would be classified in one or the other of these provinces, rather than in the residual.

The fine sandy loam type, which covers a smaller area than the sandy loam, is very similar in most respects except texture. It is underlain by a subsoil that is ordinarily not so heavy and compact as that of the sandy loam. It also contains slightly more organic matter and is a little more retentive of moisture.

Location.—Only a few areas of the soils of this group are mapped. They are confined mainly to the hilly regions in the southern part of the survey. The largest bodies lie southeast and north of El Toro and in the vicinity of Laguna Beach. Smaller areas occur southeast of Corona and north and south of La Habra.

Topography and drainage.—The topography is typically rolling, hilly, and broken. It lies on moderate to steep slopes, ridges, and smooth rounded hilltops. In detail the surface varies from smooth and rather even to eroded and dissected, where cut by numerous streams and ravines. The drainage is good to excessive.

Utilization and adaptation.—The soils of this group are not extensively used for farming. Some grain and grain hay are grown without irrigation and beans are produced on the better parts. The yields are usually low. A few vineyards have been established in the vicinity of Laguna Beach. Crops are grown without irrigation, on account of lack of water supply.

ALTAMONT LOAM.

Description.—The Altamont loam, which is derived mainly from shales and sandstones, is brown to dark brown, or in a few places reddish brown in color. The soil is friable, contains moderate amounts of organic matter, and is absorptive and retentive of moisture. At a depth of 8 to 15 inches the soil is underlain by a compact heavy loam to clay loam subsoil, of yellowish-brown or other color lighter than that of the surface soil. The subsoil hardens and cracks where exposed, but does not seriously impede root development. The parent sedimentary rocks normally lie within 6 feet of the surface.

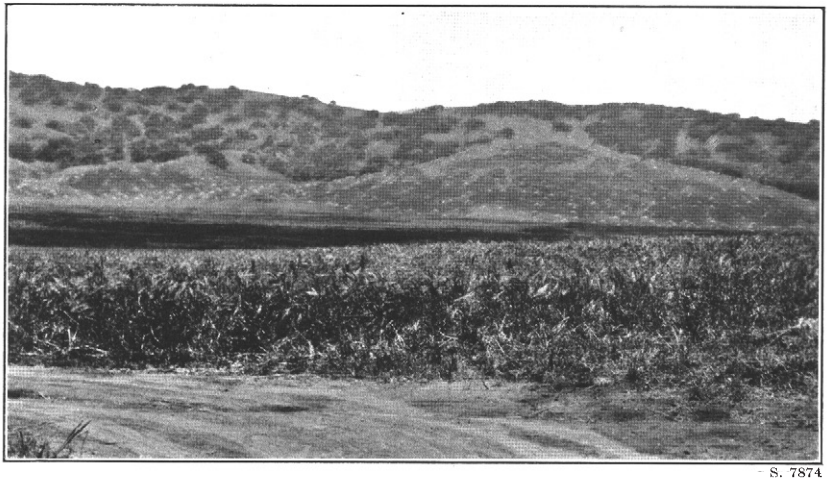
In places waterworn gravel consisting of small shale fragments occur in the soil and subsoil mass. In other sections subject to erosion, numerous patches of rock outcrop occur. The texture of the surface soil is heavier on the steeper slopes, where the surface material has been removed by erosion and the heavier subsoil material exposed. Small areas of rough, nonagricultural land occuring along the ravines and streams are included with the type as mapped.

Location.—The Altamont loam, which is much more extensive than the Altamont sandy loams, is confined to the western and southern parts of the survey. Many of the areas are small in extent. A number of moderate size lie north of Capistrano, in the district about El Toro and in the adjacent parts of the Santa Ana Mountains and the San Joaquin Hills. Other conspicuous areas occur within the limits of the city of Los Angeles. South of San Gabriel is another area, occupying a part of the hills west of the Rio Hondo. A number of small areas lie in the San Jose Hills west of Pomona, and on the lower southern slopes of the Santa Monica Mountains. There is a small area of somewhat doubtful origin south of Beaumont, in the eastern part of the survey.

Topography and drainage.—The topography is rolling and hilly to mountainous. The surface is in places smooth and the slopes rounded, but may be eroded and dissected by streams and canyons. In the steeper and more broken areas the drainage is excessive.

S. 7996

FIG. 1.—YOUNG PEACH ORCHARD ON TUJUNGA SANDS NEAR ONTARIO.



S. 7874

FIG. 2.—SOILS OF THE ALTAMONT SERIES, DEVOTED TO GRAIN HAY PRODUCTION.

Local alluvial valley in middle distance is occupied by soils of the Yolo series. These areas lie in the Puente Hills, near Walnut.

Utilization and adaptation.—A part of the type remains in its virgin condition and is used for grazing. The part farmed is used largely in the production of grain and grain hay, the yields in the better areas being fair. (Pl. II, fig. 2.) No water is available for irrigation, except in a few places. Here small plantings of citrus fruits have been made. In some of the rougher and more broken areas, eucalyptus trees have been planted.

ALTAMONT CLAY LOAM AND CLAYS.

The Altamont clay loam and clays group includes the Altamont clay loam, the Altamont clay, and the Altamont clay adobe. This is the most extensive of the residual groups in this survey.

Description.—The Altamont clay loam ranges in color from a medium brown to a rather dark grayish brown. It contains more organic matter than the loam of the series and is in many places darker in color. It is compact though moderately friable, and in the deeper parts retentive of moisture. At depths generally between 10 and 24 inches, it is underlain by a lighter colored subsoil ranging in texture from a clay loam to a clay. The soil is very sticky when wet and hardens and checks upon drying. The lime content varies considerably in the different localities, but in places is high. The subsoil rests upon the sedimentary rocks, mainly sandstone and shale.

This type of soil is subject to wide variation. In color many noticeable variations occur, the material ranging from light grayish brown to reddish brown, dark brown, or almost black. The texture and the relation of the soil to the subsoil show many differences. Many small areas of the heavier textured types of this series are scattered through the clay loam, and in a few places the soil material is uniform to the bedrock, no distinct subsoil showing. The depth of soil and subsoil also varies widely. The areas of shallow soil are in most places associated with the higher elevation and the steeper slope.

The Altamont clay is similar to the clay loam in most respects except texture. It is, however, prevailingly darker in color, ranging from a dark brown to dark grayish brown. When wet, the soil is very sticky and when dry it has a tendency to crack at the surface and assume an adobe structure. It is retentive of moisture, relatively high in organic matter, and as compared with the clay loam, more productive. The subsoil, which consists of a heavy clay, is in a greater number of cases calcareous and is more compact than that of the clay loam.

The Altamont clay adobe, coming almost entirely from shale, is very similar to the clay type of this group except in structure. It is a pronounced adobe soil, very sticky when wet and checking deeply and abundantly during dry periods. The soil is dark brown

in color and well supplied with organic matter. It is rather difficult to till except when in favorable condition as regards moisture. With proper cultivation the type is productive.

Location.—The soils of this group are developed mostly in the region west of Pomona, in the Santa Ana Mountains, and in the section south of the San Gabriel range. The areas are irregular and intimately associated with the other Altamont types and with Rough broken and stony land. A large part of the group lies in the northern part of the San Joaquin Hills between El Toro and the ocean, and between El Toro and Capistrano, while small areas are scattered at lower elevations on the western slopes of the Santa Ana Mountains. Areas also occur west of Chino Creek, in the Puente Hills, and in in the San Jose Hills. These areas lie below the rougher broken mountain region, but occupy rather rough, steep slopes that include some rougher land. Many areas of the clay adobe member of this group occur northeast of Whittier in the Puente Hills, and others cover extensive areas in the San Pedro Hills. A large area of the clay loam type lies south of Tujunga Valley, west of Sunland, and many others occur west of San Fernando, on the lower northern slopes of the Santa Monica Mountains, and northeast of Los Angeles.

Topography and drainage.—The soils of this group occupy moderate to steep slopes, rounded hills, and ridges. The topography is undulating to rolling, the surface being even and smooth except for the channels of short streams and ravines. As a whole the areas are well drained, and the run-off from some of the steeper slopes in the heavier textured soils is excessive. Nevertheless, the greater part of the type retains moisture fairly well, so that dry farming is successful.

Utilization and adaptation.—This group of soils is used almost entirely for the production of grain and grain hay, consisting mostly of barley and oats, without irrigation. While cultivation is somewhat difficult on the areas of the rougher topography and of heavier textured soils, the yields are for the most part good—generally better than those obtained on the Altamont sandy loams and the Altamont loam. Summer fallowing in alternate years is practiced to some extent and usually results in increased yields. Beans are also grown on some of the parts of the group near the coast. On account of the lack of available water supply and the rough topography very few of the areas will ever be irrigated. In the vicinity of Whittier a small acreage planted to citrus fruits is irrigated by pumping.

From one-fourth to one-half or more of the area of this group is devoted to pasture, and a considerable part near the cities is being used for building sites.

Diablo Series.

The types in the Diablo series have dark-gray to black surface soils, with variations, small areas that show a slight tinge of brown.

In places the dark-colored material extends to bedrock, but in most cases the subsoil is lighter in color, heavier in texture, and more compact than the surface soil. The series is derived from sedimentary rocks. The Diablo soils contain more organic matter, have a higher lime content, and are darker in color than the Altamont soils, but have about the same range in depth and the same general type of topography. They are usually well drained though retentive of moisture. In this survey the series is represented by the clay loams and clays which are mapped together.

DIABLO CLAY LOAMS AND CLAYS.

The Diablo clay loams and clays group includes the Diablo clay loam, the Diablo clay loam adobe, the Diablo clay, and the Diablo clay adobe. Of these the last mentioned is by far the most extensive and important.

Description.—The Diablo clay adobe is a dark-gray to black, in places brownish, residual soil derived from calcareous shale and limestone formations. The soil is, from 8 to 36 inches, a medium to heavy clay in texture and of pronounced adobe structure. When wet it is very dark in color and is sticky and plastic, and upon drying it is inclined to bake and develop deep cracks if not tilled. With the optimum moisture content it is friable and granular and can be cultivated easily, but otherwise tillage is difficult.

When properly managed and the surface material can be brought to a well-granulated friable mulchlike condition the soil is retentive of moisture, and the checking of the material is confined mainly to the first few inches of soil, which becomes a mass of small pellets or fragments. The subsoil is in most cases lighter in color than the surface soil, being generally brown or light brown to gray, but here and there dark colored material extends to bedrock. The subsoil is of heavy texture and commonly contains nodules, seams, or concretions of lime. Like the surface soil it is very compact, exceedingly sticky when wet, and cracks upon drying. Bedrock underlies the type at depths of 4 to 6 feet.

The Diablo clay adobe is subject to considerable variation in color, depth, texture, and structure. The soil is closely related to those of the Altamont series, and in many cases where the soils of this group merge into the Altamont soils the color is frequently not typical, showing much brown, similar to that of the Altamont types. The adobe structure is much more pronounced in some localities than in others. In a few places the soil mass contains a few shale fragments and a little gravel, but this is a minor variation. On some of the steep slopes the underlying shales are exposed in many places, and the soil in such localities is shallow. At the base of slopes and on some of the more nearly level areas the soil is much deeper than else-

where and the areas are more easily cultivated and yield better than most of the type. Around the San Pedro Hills many areas occupy marine terraces. These differ from the typical soil in topography.

The Diablo clay loam adobe is similar to the Diablo clay adobe except in texture. It is of small extent and so closely associated and related to the Diablo clay adobe that the two types are very difficult to distinguish and differentiate in the field.

The Diablo clay and clay loam, about equal in extent, occur in only small areas in this survey. They are very similar to the Diablo clay loam and clay adobe except that they lack the adobe structure. As a whole they are more friable and not so compact as the adobes. They also contain less organic matter and hence are lighter in color. They are more subject to erosion than the adobe types.

Location.—The soils of this group are situated in the hills and mountains and occur for the most part in association with Rough broken and stony land and the Altamont types. The largest areas of the clay adobe type lie in the San Pedro Hills. Small areas occur southwest of El Toro. A short distance northeast of Capistrano is an area consisting mainly of the clay loam adobe. Several bodies of the Diablo clay are situated in the Puente Hills east of Los Angeles. These are of a pronounced brown color and are as closely related to the Altamont as to the Diablo series, and in the detailed soil survey of the Pasadena area are regarded as representing a dark-colored phase of the Altamont clay. The areas mapped on the lower northern slopes of the Santa Monica Mountains are mainly the Diablo clay loam.

Topography and drainage.—The topography is probably somewhat more subdued with less steep slopes and fewer ravines and draws, than in case of the Altamont soils. The surface is moderately rolling or undulating to hilly and mountainous. Parts occupy marine terraces, and much of the surface is comparatively smooth, but there are rough mountainous areas with steep slopes and ravines included. The drainage is good. While the soils do not absorb moisture as readily as those of lighter texture, they retain moisture well.

Utilization and adaptation.—As a whole these soils are used principally in the production of grain and grain hay, which give good yields without irrigation. Practically none of the soils are irrigated, as there is no readily available water supply and the topography is unfavorable to distribution of water even where it might be obtained. In the San Pedro Hills, chiefly in the terrace areas, considerable quantities of truck crops are grown without irrigation. The yields are usually good and the crops mature early, as the dark-colored soil warms up early in the spring and the areas are favorably situated with regard to exposure and freedom from frosts. A few small areas are used in the production of beans. While fairly good yields

are obtained, the crop ordinarily does better on the lighter textured soils. Little fertilizer is used, but grain growers commonly fallow their land in alternate years, which increases yields considerably. A part of the type is utilized only for pasture.

OLD VALLEY-FILLING AND COASTAL PLAIN SOILS.

San Joaquin Series.

The soils of the San Joaquin series are red to light red in color, with variations of yellowish-red, brownish-red, or pronounced reddish brown color. They have been formed from unconsolidated water-laid deposits, derived from many different kinds of rocks. The soils are underlain at depths ranging from a few inches to 3 feet by a very compact subsoil, which is usually redder in color and heavier in texture than the surface soil, and which rests upon a red or reddish-brown, practically impervious hardpan. The hardpan varies in thickness from a few inches to several feet. It consists of the material similar to that forming the subsoil, cemented by precipitation of iron salts carried in solution by percolating water. The hardpan is generally underlain by a more permeable substratum which resembles the surface material. The soils are low in content of organic matter, contain little or no concentrations of lime, and have a tendency to bake and become droughty during the dry season. The soils occupy sloping or undulating to rolling valley plains which in this survey occur for the most part along the slopes adjacent to the mountains and foothills as remnants of formerly more extensive areas. The surface is generally marked by conspicuous low mounds and intervening shallow depressions or "hog wallows." The soils are either without tree growth or support a scattering growth of oaks. Owing to the impervious hardpan and to the accumulation of surface water in the depressions, the soils become wet and boggy during the rainy seasons. One group, comprising the loam and sandy loam, is mapped.

San Joaquin loam and sandy loam.

This group of soils, comprising an area of 8,896 acres, includes only the San Joaquin loam and the San Joaquin sandy loam types, of which the former is the more extensive.

Description.—The San Joaquin loam is a pronounced reddish brown to red loam 8 to 24 inches deep. It is nonmicaceous, rather compact, gritty, and low in organic matter. Where the soil is deep it is moderately absorptive of moisture and retains water well. It is very sticky when wet, and upon drying tends to harden and clod unless properly cultivated. The subsoil, which is heavier than the surface soil, ranges in texture from a heavy loam to a clay. It is of compact structure and redder than the surface soil and like the latter is more or less gritty. At varying depths below the surface, generally

between 2 and 4 feet, it rests upon a reddish hardpan. This varies greatly in thickness, but is ordinarily a hindrance to subdrainage and to root development. Below the hardpan is a more friable reddish-brown to red stratum similar in most features to the surface soil. It ranges in texture from a sandy loam to a loam and is quite permeable.

Several variations of this soil occur. On slightly elevated parts it is lighter in texture and in depressed areas where standing water collects during the wet season it is heavier and more compact and in many places puddled. Mapped parts of the type probably lack the hardpan and parts contain some gravel and are more gritty than typical.

The San Joaquin sandy loam is similar in all respects to the loam except in texture, which makes the former less retentive of moisture.

Location.—This group of soils is confined mainly to one area in the upland region southeast of Riverside, in the vicinity of Box Springs and Alessandro. A small area is mapped a short distance north of Glendale and just west of Verdugo Canyon, and there are a few small areas of typical San Joaquin material in this vicinity and in the Eagle Rock Valley which on account of their small extent were included with Madera soils.

Topography and drainage.—The group occupies an elevated plain with a generally level to slightly undulating topography. In detail the surface consists of a succession of hummocks and depressions, but this "hog-wallow" configuration is not as marked in this region as in areas in other parts of the State. The drainage is fairly good. In some of the depressions water accumulates during the rainy season, and owing to the presence of hardpan, which interferes with percolation, the soil and subsoil become quite boggy.

Utilization and adaptation.—The soils are used almost entirely in the production of dry-farmed grain and grain hay. At present no gravity water is available for irrigation. Fertilizers and manures are not used, though they without doubt would increase production. Summer fallowing is practiced to some extent. The soil areas are well supplied with roads and other lines of transportation.

Placentia Series.

The soils of the Placentia series range in color from red to pronounced reddish brown, with a tendency to become redder when wet and more brown when dry. The subsoil is in most places redder and heavier than the surface soil and very compact, and in some places partly indurated. It contains thin gravelly strata of variable thickness. The soils are derived from materials coming mainly from granitic rocks. They are low in organic matter, deficient in lime, and inclined to bake and clod if not cultivated during the dry season, but

are well drained and without accumulations of alkali. They occupy remnants of old eroded alluvial fans, lying near the base of the mountains, as well as elevated mesas and plains of uniform to undulating topography. (Pl. III, fig. 1.) The Placentia series is distinguished from the San Joaquin series by difference in origin and by the absence of hardpan. The Placentia sandy loam and the Placentia loams are mapped.

PLACENTIA SANDY LOAM.

Description.—The surface soil of the Placentia sandy loam is a reddish-brown to red, light to medium textured sandy loam. The soil is a stronger red when wet and a brown or light reddish brown when dry. It is micaceous, friable when properly cultivated, and is easily tilled, but rather low in humus and lime, and has a tendency to bake slightly in dry weather if uncultivated. At a depth of 10 to 16 inches it passes into a subsoil of red or reddish heavy and compact loam or clay loam. The subsoil material is gritty and micaceous. When wet it is very sticky and when dry hard and flinty. On account of its dense and compact structure it offers considerable obstruction to the development of roots and interferes with the movement of moisture and with aeration.

The soil is subject to more or less variation in color and some material of rather brown or grayish-brown color is included. Minor areas of Ramona and Hanford soils may be included in such cases. Locally small areas of Placentia material have been covered with a thin veneer of recent alluvial material, and in places considerable quantities of gravel and stone occur. Here and there the subsoil may be composed mainly of gravelly deposits. Small areas having an iron cemented hardpan occur and these if more extensive would be mapped as soil of another series.

Location.—The type contains 37,056 acres. It is confined mainly to the eastern part of the survey, the most extensive bodies occurring in the vicinity of Beaumont and north of the San Timoteo Canyon, extending thence nearly to Mill Creek. Two or three small areas lie near Redlands, a few west of Riverside and Arlington, some well-developed areas near Ethanac and Murrietta northeast and southeast of Elsinore Lake, and others north of Corona. Some of the soil in the Yucaipe Valley is rather heavy and probably includes areas of the loam or clay loam of the series.

Topography and drainage.—The type has a varied topography ranging from the steep dissected surface alluvial fans, in the vicinity west of Oak Glen, to rather gently sloping surface of elevated plains in other sections. For the most part the surface is smooth and even, with gentle slopes or slightly undulating relief, except where cut by stream ways. A few small areas have a hilly and broken topography, but these are not typical. Surface drainage is always good; though

the heavy subsoil interferes with the internal movement of moisture, the type as a whole is absorptive and retentive of moisture.

Utilization and adaptation.—In the past the production of grain and grain hay under dry-farming methods was important on this type, but with the development of water for irrigation much of the land recently has been planted in fruits. A part of the type is still used for the production of barley and oats. Fertilizers are not used for these crops, summer fallowing being the only step taken to maintain the yields. A few areas are in alfalfa, which gives good yields.

In the Yucaipe Valley about 5,000 acres has been planted to deciduous fruits, largely apples, and practically all the orchards are on the Placentia sandy loam. The majority of the trees are from three to nine years old. The orchards are irrigated. Near Beaumont extensive plantings of apples and less important plantings of apricots, peaches, pears, and cherries have been made on the Placentia sandy loam type. The orchards generally consist of 5 to 40 acre tracts. In managing these orchards practically no commercial fertilizers are used and cover crops are seldom planted, but manure is used where obtainable.

PLACENTIA LOAMS.

The Placentia loams group consists of the loam, gravelly loam, and the clay loam of the series. The loam has the greatest extent and is agriculturally the most important of the soil types.

Description.—The Placentia loam, to a depth of 10 to 18 inches, is a reddish-brown to red medium textured micaceous loam, containing more or less small angular sharp, granitic fragments, which give it a gritty feel. The soil is low in organic matter and moderately compact, but is tilled easily under favorable moisture conditions. If plowed when wet it clods, and if allowed to go too long without cultivation the surface becomes very hard. The subsoil is in most places redder than the surface soil, but variations of grayish to yellowish brown color are met with. It is heavier in texture, ranging from clay loam to heavy clay, is very dense and compact, and in many places obstructs the growth of roots and the percolation of water. At 4 to 5 feet it grades into a substratum very similar in most respects to the surface soil, except in color, which is lighter.

The Placentia gravelly loam differs from the Placentia loam type mainly in texture, which is modified by the addition of varying proportions of gravel. In most cases the content of such coarse material is not sufficient to interfere seriously with cultivation, and it is only in some of the steep alluvial fans that the bowlders and rock fragments are detrimental. The gravelly loam normally contains more grit in the soil and the subsoil than the loam, and as a whole is of lighter texture and contains less organic matter. The subsoil

is in many places composed of unassorted material consisting of gravel and stone, with some finer interstitial material.

The Placentia gravelly loam is confined to the tops of ridges and to steeper slopes, and forms the remnants of old alluvial fans and other dissected areas of undulating, rolling, or broken topography. In this survey the type is restricted almost entirely to small irregular tracts along the lower slopes of the San Bernardino Mountains between San Antonio Canyon and Highlands. As compared to the Placentia loam it is an inferior soil. In this survey it is not well situated for irrigation and it is largely used for pasture, though on the better parts grain is grown without irrigation and in the places where water is available for irrigation some fruit trees have been planted.

The Placentia clay loam type, of which there is also a very small area, is similar in most features to the Placentia loam. It probably varies more in color than the loam, but the principal difference between the two is in texture. The clay loam has a comparatively heavy texture for a soil of its class and includes some small areas of clay. It is much more sticky and puddles more easily when wet than the loam, and forms clods more readily and is more compact when dry. The subsoil is heavier and more compact than the soil and there is a tendency to hardpan in places.

Only a few areas of this type occur. These lie in the vicinities of Corona, Arlington, and Riverside. Some grain, sugar beets, alfalfa, and citrus fruits are produced on this soil, but the yields are lower than those on the Placentia loam.

Numerous variations occur in the soil group as mapped. It includes small bodies of Montezuma and Ramona soils, as well as some recent alluvial deposits and small areas of Rough broken and stony land. In some localities the soil, owing to a higher content of organic matter, is darker in color than typical, and some of the extremely old deposits that are highly oxidized are much redder than the average. In a few places an iron-cemented hardpan has developed, but it is noncontinuous and varies greatly in thickness. If more extensive these areas would be classified as soils of a distinct series. Other variations found in some localities consist of the presence of strata of gravel or silty material in the subsoil.

Location.—The larger and best developed areas of the soils of this group in this survey lie in the country around Riverside and Redlands. One of the more important bodies is south of Redlands and Crafton, where it occupies high, dissected mesas between Redlands Junction and the Crafton Hills. Other notable areas are situated between Colton and Riverside and between Riverside and Corona. Many areas, consisting mostly of old alluvial fans, are mapped in the vicinity of the Jurupa Mountains. An isolated area lies south of Ethanac,

other small bodies south of Beaumont, northwest of Banning, and in the vicinity of Corona. Southwest and northwest of Yucaipe other developments occur, and there is a moderate sized area of stony character between the Santa Ana River and Mill Creek, near the base of the San Bernardino Mountains. West of this body other areas occur along the lower slopes of the mountains as far as the San Fernando Valley.

Topography and drainage.—The country occupied by the Placentia loams consists of elevated terraces, mesas, and alluvial fans, which in part have been eroded until the surface is undulating to broken. Other parts are gently sloping, smooth, and easy to irrigate and cultivate. The small areas lying along the lower southern slopes of the San Bernardino and San Gabriel Mountains are remnants of old alluvial fans, and have a dissected and eroded surface. The drainage, except in one or two small areas near Arlington, is good and the group as a whole is free from alkali accumulations. The soils do not absorb moisture as readily as the sandy loam type of the series, but as a rule they retain it better.

Utilization and adaptation.—This group of soils, especially the loam member, is used extensively for the production of oranges, and while it is not the most extensive, it is one of the most important soil groups in the agriculture of the area. Some of the first orange groves in Southern California were located on the Placentia loam, and they apparently are still highly productive. Lemons, walnuts, and olives are grown also, but only in small quantities, the last two named in many cases being planted as border trees around the orange groves. On some of the areas not so well situated climatically for the culture of citrus fruits, apricots, peaches, and grapes are grown successfully, and other parts of the type are used in the production of alfalfa, sugar beets, and grain. Considerable quantities of commercial fertilizer and barnyard manure are used in the citrus groves, and cover crops are grown to some extent and turned under as green manure. Clean cultivation is the practice in many of the groves, however. A small part of the group, situated along the lower slopes of the mountains on eroded fan areas, is not used in cultivation, but is utilized for pasture. Except grain, practically all the crops are irrigated.

The soils of the group are usually well situated with respect to markets and are traversed by good wagon roads. Practically none of the important areas are inaccessible.

Ramona Series.

The soils of the Ramona series are brown, with reddish-brown and grayish-brown variations. The subsoil encountered at depths of 10 to 24 inches is in most areas heavier in texture, lighter in color, and

more compact than the surface soils. The soils have been formed from unconsolidated water-laid deposits derived mainly from granitic rocks. The surface is smooth and gently to moderately sloping, or undulating and uneven, with more severely eroded areas cut by deeply entrenched drainage ways. The soils are for the most part noncalcareous, well drained except in local depressions and flats, and are free from alkali. In this survey one individual type and three groups of types of this series are mapped. The Ramona series is closely related to the Placentia series from which it differs in color and usually in the somewhat less dense and compact nature of the subsoil.

RAMONA STONY LOAMS.

This group of Ramona stony loams includes the Ramona stony sandy loam and the Ramona stony loam.

Description.—The Ramona stony loam, the more extensive soil in this group, is a brown to slightly reddish brown soil, of medium to heavy loam texture, carrying excessive quantities of bowlders and smaller rock fragments. In places the quantity of stones is more than 50 per cent of the soil mass. The soil is low in organic matter, gritty, micaceous, and friable. Generally at depths between 12 to 18 inches, the soil is underlain by a light-brown to reddish-brown, in a few places yellowish-brown, subsoil, more compact than the surface soil and ranging in texture from a heavy loam to a clay loam. The subsoil contains large quantities of unassorted material consisting mostly of large bowlders and gravel of igneous rocks, with which finer material has been mixed. In many instances the bowlders are partly weathered and visibly disintegrating.

The Ramona stony sandy loam, which, as the name implies, is of lighter texture than the stony loam, is more porous than the latter, and its subsoil is not so compact and heavy. In many places the subsoil is very similar in color and texture to the surface material. It contains in some places considerable quantities of fine gravel and coarse sand and as a whole, is more gritty than the stony loam. It absorbs water more readily but does not retain it as well as the loam type.

Location.—All the areas of this group are comparatively small and unimportant. The largest occur in the San Bernardino Mountains south of Bear Lake and Baldwin Lake, in the vicinity of Convers Flat on the north side of the Santa Ana River, near Seven Oaks, at Big Meadows near the headwaters of the Santa Ana River, and areas north and northeast of Highlands. There are also a few small areas near the junction of Lone Pine and Cajon Canyons. Two comparatively large areas and several small ones occur in the San Gabriel Mountains east of Soledad Canyon and south and southeast of Acton. The better areas for agricultural use lie between Temescal and Elsinore

east of the Santa Ana Mountains. Small elongated and very stony areas are situated south of Elsinore Lake, and a few areas of the stony sandy loam type are developed northeast of San Fernando, and in the vicinity of Sunland.

Topography and drainage.—The group occupies knobs and ridges having steep slopes but with rather even surfaces, and remnants of elevated plains. In general the topography of these areas is usually undulating to rolling or hilly. Only a small part of the soils would be suitable for irrigation were water available. Drainage is good to excessive.

Utilization and adaptation.—Practically none of the areas of this group are tilled and probably the greater part owing to the topography, the excess of stones, and unfavorable conditions for irrigation never will be. Some of the areas also are poorly supplied with roads and occur in remote mountain regions. At present a dense cover of brush with larger trees at high elevations covers most of the land.

RAMONA SANDY LOAMS.

The Ramona sandy loams group includes the Ramona sandy loam, the Ramona fine sandy loam, and the Ramona sand types, of which only small areas occur.

Description.—The Ramona sandy loam is a brown to slightly reddish brown light to medium textured sandy loam. In many areas it contains small, angular, rock particles which give it a more or less gritty feel. It has a moderately loose open structure, is usually low in organic matter, and in its natural condition has a tendency to bake. It is absorptive but the quantity of water it can carry depends largely on the depth to and the texture of the subsoil. The subsoil, which is normally redder than the surface soil, is generally encountered at 10 to 24 inches below the surface. It consists of compact heavy loam to clay loam, which becomes hard and flinty upon exposure to the air. At a varying depth, in most cases about 6 feet, it merges into a more permeable stratum closely resembling the surface material in texture and color.

This type varies considerably from place to place. Gravelly areas and areas containing more or less stone and bowlders occur. The soil varies also in depth, and where the texture is lighter the subsoil is likely to lie at greater depths. In some places near the residual soils the soil and subsoil material may be underlain at shallow depths by bedrock. In a few instances thin layers of hardpan and of calcareous material exist in the subsoil, but such occurrences are comparatively rare and of small extent. In the areas southeast of Elsinore, there occur areas of the Placentia soils, commonly occupying slight elevations where erosion has been active. In the Morongo Valley, in the extreme eastern part of the survey, the soil seems to consist

mainly of the Ramona sandy loam, but it has characteristics, for example, a peculiar structure and a relatively high lime content, that are common in the desert soils, and it is possible that this soil area should have been included with the Mohave instead of the Ramona series. West of Cajon Pass in the San Bernardino Mountains three areas were mapped with this group but they do not have the typical Ramona topography and resemble the desert soils in many respects. They also include some recent alluvial material and as a whole are more or less gravelly and stony.

The Ramona fine sandy loam is very similar in most features to the Ramona sandy loam, but contains more fine material and is not so gritty. It is more retentive of moisture, slightly more compact, and when considered as a whole, it probably is more productive than the sandy loam.

The fine sandy loam has many variations but most of those are similar to those described in connection with the Ramona sandy loam. The fine sandy loam probably varies more in color than the sandy loam.

The surface soil of the Ramona sand is a light-brown to a slightly reddish brown sand or loamy sand, containing a small proportion of organic matter. The subsoil, encountered at 24 to 36 inches, is similar in color, but slightly heavier in texture and a little more compact than the surface soil. The heavy compact subsoil, which is a prominent characteristic of the heavier types of the Ramona series is not well developed in the Ramona sand. As a whole it absorbs moisture more readily than the other types of the series, and, considering its light texture and porous structure, it is also very retentive.

Location.—The most extensive area of the sandy loam type extends from the vicinity of Perris in a northerly direction to Pigeon Pass, east of the Box Springs Mountains. Other rather important areas, although somewhat eroded and dissected in places, lie in the region east of the Santa Ana Mountains and extending from Elsinore in a southeasterly direction to the southern boundary of the survey. The most important areas of the fine sandy loam type lie between Redondo and Alamitos Bay, mainly south of Nigger Slough and north of Long Beach. Other areas of this group are developed in many parts of the survey.

Topography and drainage.—The soils of this group occcupy remnants of old Coastal Plain, alluvial deposits, and alluvial fan deposits. These areas, though in some cases more or less eroded, have in general a slightly undulating topography that generally allows irrigation. (Pl. III, fig. 2.) In some of the larger areas the surface is marked by "hog wallows" somewhat similar to those typifying the San Joaquin soils. The Ramona soils nearly always lie above the recent alluvial soils, and as a whole the types are well drained and free

from alkali, except in some depressions in filled-in valleys, where the subsoils are exceptionally heavy and compact.

The topography of the Ramona sand is more undulating than that of the other types in the group, and closely resembles the topography of the wind-laid Oakley sand. The surface material of the Ramona, which at present is not subject to movement by winds to any great extent, has doubtless during the past been more or less modified by wind action. This type is fairly well adapted to irrigation, but requires large quantities of water to meet the demands of crops.

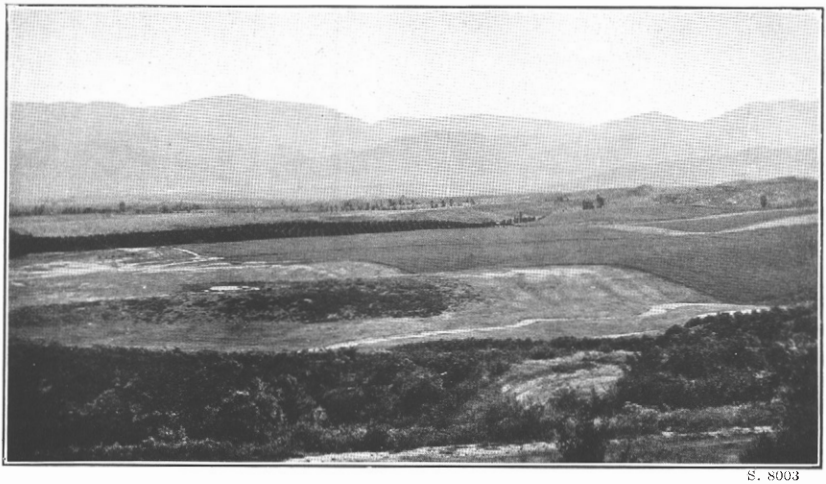
Utilization and adaptation.—These soils are used mainly in the production of dry-farmed grain and grain hay, with the largest acreage in the regions southeast of Elsinore and north and southeast of Perris. Moderately good yields are obtained, and yields are considerably increased where summer fallowing is practiced. Beans are also grown quite successfully on a part of the soils, lying for the most part near the coast. Grapes also are grown, without irrigation to some extent. Where irrigation is available the crops include citrus fruits, walnuts, deciduous stone fruits, olives, alfalfa and truck crops. Commercial fertilizers and manures are used only for the more important fruit crops. Winter cover crops are grown more or less in the orchards and turned under in the spring, with apparently good results.

Excepting some of the small outlying areas in the mountain region which are remote and utilized mainly for grazing, the soils of the group as a whole are well supplied with roads, and are fairly accessible to markets. The nonirrigated grain land sells at $40 to about $100 an acre; some of the well developed irrigated orchard lands range up to $1,000 or more an acre.

RAMONA LOAMS.

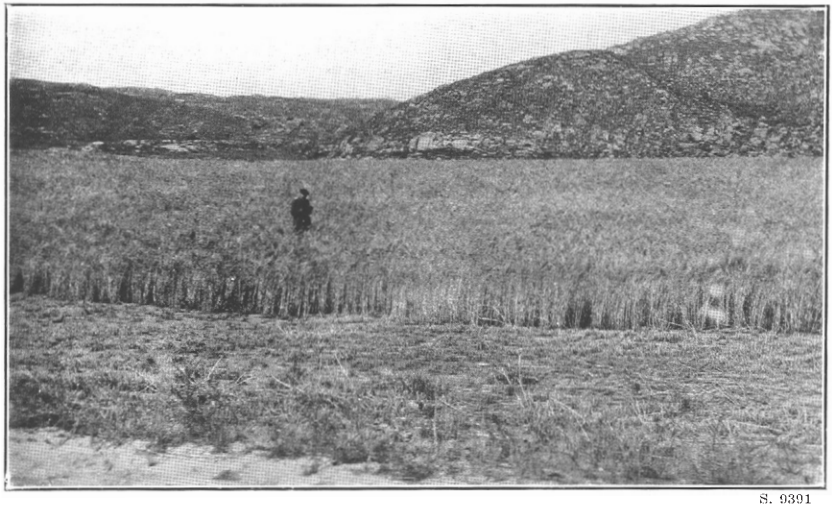
The Ramona loams group, which includes the Ramona loam and the Ramona gravelly loam types, is one of the more extensive and important soil groups of the survey. It covers 166,656 acres.

Description.—The Ramona loam, which greatly predominates, is a brown to slightly reddish brown heavy sandy loam or light loam to a heavy loam, with a variation of grayish-brown color. The soil ranges in depth from 10 to 24 inches, is in many places micaceous, is sticky when wet and rather compact, and hardens upon drying if uncultivated. In poorly drained depressions the soil is sometimes puddled. The subsoil consists of brown to reddish-brown clay loam to clay, compact and dense in structure extending to a depth of 4 to 6 feet. It is sufficiently hard to prevent the percolation of water and to obstruct more or less the proper development of the root systems of deep-rooted plants and trees. The subsoil material contains in many places finely divided mica and varying quantities of gritty particles. When wet it is sticky and where exposed it



S. 8003

FIG. 1.—OLD VALLEY-FILLING SOILS OF THE PLACENTIA SERIES NEAR REDLANDS, SHOWING CHARACTERISTIC ROLLING TOPOGRAPHY.



S. 9391

FIG. 2.—GRAIN ON RAMONA SANDY LOAMS IN DIAMOND VALLEY, NEAR HEMET, SHOWING SMOOTH BUT SLIGHTLY UNDULATING TOPOGRAPHY.

Rough broken and stony land in distance.

becomes flinty and hard and cracks upon drying. The substratum is in most cases, but not everywhere, lighter in texture than the subsoil. It may consist of a loam or light clay loam closely resembling the surface soil, or of stratified beds of gravel, silt and sand.

The Ramona gravelly loam covers a small area. It is similar to the Ramona loam except in gravel content, which may range from 10 to 25 per cent of the soil mass. It varies greatly in size and other characteristics, but in most areas is rounded to subangular in shape. The soil is very low in organic matter. As a whole it absorbs moisture more readily than the loam type. The subsoil, encountered at a depth of 10 to 20 inches, is similar to that of the Ramona loam, except that it contains many large boulders and stones.

The material of these types as mapped is subject to considerable variation. Some of the areas contain more organic matter than typical and include small areas of Montezuma soil where the two series merge into each other. These bodies are always darker in color than the typical Ramona soils and in many places contain streaks or concentrations of lime in the subsoil. More or less material of the Antioch and Placentia series also was included, where owing to intimate association and occurrence in small areas, it was not practical to separate it. Another variation occurs in some of the areas adjacent to the residual soils, the material here being thin and underlain by consolidated bedrock. The soil material is also subject to considerable range in texture, being in places light and containing gritty particles, and in others much heavier. Southwest of Inglewood material of silty loam texture is included. The soil here is smooth and friable and normally deeper than the typical Ramona soils. It also is more retentive of moisture, and easier to cultivate. In various places, and especially east and west of Los Angeles, streams from the higher lands have deposited a veneer of recent alluvial material, from a few inches to a foot thick, over the surface of the old valley-filling types.

Location.—This group of soils is extensive and widely distributed. The larger and more important areas occur in the western and southwestern parts of the survey, particularly in the region between Hollywood and the San Pedro Hills, and in the vicinity of Pasadena and southward nearly to Downey. It is also well developed south of Whittier, and north of Long Beach.

The most important gravelly portions of the type occur in the vicinity of Orange, Wanda, El Modena, and along Santiago Creek, and east of El Toro. Several other areas lie near Pasadena, Alhambra, and San Gabriel.

Topography and drainage.—These types occupy remnants of old alluvial fans and gently sloping plains and terraces composed of old marine or alluvial deposits. A few areas are hilly and broken, but

the greater part of the types have rather smooth and even surfaces, slightly rolling and undulating in places, but not so much so as to interfere seriously with irrigation. The areas occur at higher elevations than the recent alluvial soils, from which they are separated in places by distinct bluff lines, in other places the soils of the two provinces merge gradually into each other. The areas in many cases lie along or are traversed by gullies or ravines, generally deeply entrenched, which promote good drainage over much of their extent. Nevertheless during the wet season water accumulates and stands in the depressions in the more nearly level areas for long periods, owing to the heavy compact subsoil and to the unfavorable topography. In the sections north of Signal Hill, and around Nigger Slough the drainage is extremely poor and some accumulation of alkali has taken place. Similar conditions obtain in some of the small valleys in the southern part of the survey, such as the Menifee, Domenigoni, and Diamond Valleys, but as a whole the soils of this group are well drained and not seriously affected with alkali.

Utilization and adaptation.—Most of the soils of the group are under cultivation. Over some of the areas cities and towns are extending and some of the more remote or badly eroded land, such as some of the fragmentary terraces and areas in the northwestern part of the survey and elsewhere in the mountain region, still remain in their native condition and are used for pasture. A large proportion of the group is dry farmed, grain and grain hay giving moderate to good yields. Beans are grown in the districts adjacent to the coast. Where water is available more intensively cultivated crops are grown. The irrigated area forms a considerable proportion of the group. Where climatic conditions are favorable, as around Whittier, Los Angeles, and San Dimas, oranges and lemons have been extensively planted, and in other districts, as at Inglewood and Gardena, large acreages are devoted to truck crops. In other sections walnuts, olives, deciduous fruits, and alfalfa are the prevailing crops. The citrus fruits and truck crops receive considerable quantities of commercial fertilizer, as well as barnyard and green manures, but the other crops are commonly grown without the use of fertilizers.

The areas of these soils are as a whole well located with respect to markets. A few of the smaller mountain areas are remote and relatively inaccessible. The land values have a very wide range. Some of the more attractively situated areas with well developed orange groves sell for $2,000 to $3,000 an acre, while some of the badly eroded, or less accessible tracts, utilized only for pasture, have a low value.

RAMONA CLAY LOAM.

Description.—The Ramona clay loam is a brown to a dark-brown light to heavy micaceous clay loam 10 to 20 inches deep. It is compact and when wet sticky, and becomes hard and flinty when dry,

clodding badly if cultivated when the moisture conditions are unfavorable. It does not absorb water so readily as the lighter textured Ramona soils, but when once thoroughly moist it is very retentive, especially if properly cultivated. On the whole the content of organic matter is larger than in case of the greater part of the loams and sandy loams of this series. The subsoil is generally redder than the surface soil, is more dense and compact and ranges in texture from heavy clay loam to clay. It is sufficiently dense to retard the root development and to obstruct the percolation of water. At a depth of 4 or 5 feet it is underlain by a stratum lighter in color and texture. This may extend to a depth of many feet. The texture of this substratum may be uniform, but commonly it consists of stratified material containing more or less gravel.

The Ramona clay loam is subject to considerable variation in texture and other features. The soil of heavier texture is usually confined to the level and depressed areas and in many places contains more organic matter and is much darker in color than the greater proportion of the type. In such areas the subsoil contains seams and nodules of calcareous material and closely resembles the subsoil of the Montezuma series. Some of the depressed, heavy textured bodies also have been puddled through improper cultivation and irrigation. The lighter textured areas have slightly undulating topography. The soil here is lighter in color and more porous. It is more gritty than the average and contains more or less gravel. In some of the hilly or mountainous sections near areas of the residual soils, the soil and subsoil material is very shallow and rests on granite bedrock. These areas, however, are of small extent. In some places where the topography of the old valley-filling material gradually merges into that of the lower lying adjacent alluvial types, the Ramona clay loam has been covered with a veneer of recent alluvial deposits, variable in depth, and the type as mapped includes small areas of recent alluvial soils. Considerable variations in color also occur. Thus in some of the eroded areas the soil is reddish brown, resembling more or less closely the Placentia soils.

Location.—The type has much smaller extent than the Ramona loams group. It occurs in the same general regions, and is most extensive in the western part of the survey. Well developed areas lie west of Los Angeles and south and southwest of Hollywood, north and southeast of Inglewood, west of Nigger Slough, and north of Bixby Slough. Other areas are distributed in various parts of the survey.

Topography and drainage.—In topography the clay loam is similar to that of the other types of the Ramona series. It is typically confined to the eroded alluvial fans, to coastal plain and valley ter-

races, and to plains and mesas, all representing areas of old alluvial or marine deposits. The surface of the greater part of the type is such that irrigation is possible without much leveling, and the relief of much of its area is sufficient to give moderately good drainage. Only in some of the low depressed areas, where water accumulates and stands during the wet season, is drainage very poor. Some alkali exists in these areas. Notable instances of this kind are seen in parts of the areas lying north of Long Beach, and in the Menifee Valley.

Utilization and adaptation.—The Ramona clay loam is a relatively important soil. It is used for a wide range of crops. Where irrigation is not feasible or has not been developed grain and grain hay, consisting chiefly of barley, are the principal crops. The yields are fairly good. Beans are also successfully produced without irrigation in the areas lying near to the coast. With irrigation citrus fruits and walnuts are grown successfully on the areas of this soil in the Whittier and La Habra sections, and deciduous fruits and alfalfa are produced where the climate is unfavorable for orange and lemon culture. Olives have been planted extensively on the type north of La Mirada, and truck crops are grown in the vicinities of Los Angeles and some of the other cities and towns.

The citrus and walnut groves receive considerable applications of commercial fertilizer, and green manure and barnyard manure are also used to maintain productiveness but most of the other crops are grown without fertilizers. The soil as a whole is more difficult to cultivate effectively than the Ramona loam type, and it is easily clodded and puddled. By turning under cover crops and applying stable manure and by deep and thorough cultivation, this condition can probably be somewhat improved. Most of the type is accessible to markets and important shipping towns.

Pleasanton Series.

The types included in the Pleasanton series have brown, light-brown, grayish-brown, or slightly reddish brown soils and a light-brown subsoil, more compact in structure and heavier in texture than the surface soils. At depths less than 6 feet the subsoil typically is underlain by beds consisting of rounded gravel, in this survey mainly of quartzose or schistose rocks, mixed with varying proportions of finer material. This gravelly stratum is one of the more prominent characteristics of the series. The Pleasanton soils occupy remnants of old terraces and alluvial fans lying between the residual and recent alluvial soils. The surface varies from smooth or undulating to rolling to hilly. The soils are medium to low in organic matter, well drained, and in most areas give little indication of concentration of lime in the subsoil. The series differs from the Ramona

series in origin of materials, most of which in this area come from sedimentary rocks, and in being underlain by a gravelly strata. The series in this survey is represented only by the Pleasanton loam.

PLEASANTON LOAM.

Description.—The Pleasanton loam consists of a light-brown to medium-brown or dark-brown medium textured loam, from 12 to 36 inches deep, more or less gritty, friable, and commonly low in organic matter. The subsoil ranges from a heavy loam to a light textured clay, varying in color from brown or light brown to slightly reddish brown. It is not so dense and compact as the subsoils of some of the loams derived from old valley-filling material and is underlain at varying depths by a very gravelly stratum, which in most areas is several feet thick. Beneath this in many places there occurs an alternating strata of sand, clay, and gravel.

The Pleasanton loam is subject to considerable variation in gravel content, color, texture, and other features. The occurrence of very gravelly areas, especially near the mountains, is common, and small areas are included that are heavier than the typical material. Variations consisting of reddish soil were observed, and in several places the gravelly substratum is poorly developed or not continuous. These small included areas are of the Ramona soils and of other Pleasanton soils.

Location.—Only a small area of the Pleasanton loam is developed in this survey. It is confined to the extreme western part of the survey near the ocean and just south of the Santa Monica Mountains. The largest and most important bodies lie between Santa Monica and Sherman, and small areas are mapped southeast of Santa Monica and northeast of Palms.

Topography and drainage.—The topography is gently sloping to slightly undulating and the surface is smooth and even except where broken by mountain streams and small ravines. The areas lie at elevations considerably above the recent alluvial soils. They occupy mainly the remnants of old alluvial fans formed by streams from the Santa Monica Mountains, and to some extent small marine terraces. The type is well drained and contains no alkali. On some of the steeper slopes the run-off is excessive and the heavy subsoil has been exposed through erosion.

Utilization and adaptation.—The greater part of the Pleasanton loam is used for growing grain hay, grain, and lima beans, which are produced with fair success under dry farming methods. The soil and topography are both favorable for irrigation, but only a few small areas are irrigated, owing to lack of water. Lemons and other crops have been planted where irrigation can be employed. The type is well situated with respect to markets.

MADERA SERIES.

The soils of the Madera series are brown, the lighter textured types being light brown or grayish brown, while the heavier types are reddish brown to dark brown. The soils are underlain at various depths by a brown or reddish-brown, rather compact, heavier textured subsoil which rests at a depth of less than 6 feet, upon a grayish-brown, or reddish iron-cemented hardpan. This hardpan normally is not so hard as that of the San Joaquin soils and is in many places somewhat mottled with concentrations of lime. Below the hardpan is a stratum of more pervious material, very similar in texture and color to the subsoil. The soils in general have a more even surface and a less pronounced development of "hog wallows" than the soils of the San Joaquin series. They occupy a position like that occupied by the San Joaquin soils, the two being closely associated. The surface is gently sloping or undulating to rolling. The Madera soils are distinguished from the Pleasanton soils by the absence of the gravel substratum and by the occurrence of hardpan, and from the San Joaquin soils by difference in color. The soils are well drained. The materials giving the Madera series are derived from rocks of various kinds. It is represented in this survey by one group of sandy loams.

MADERA SANDY LOAMS.

Description.—The group Madera sandy loams includes the fine sandy loam and sandy loam types of the series.

The Madera fine sandy loam is a brown to light-brown or somewhat grayish brown fine sandy loam ranging in depth from 6 to 20 inches. It is generally low in organic matter, but is friable and fairly easy to till. The subsoil is more compact and dense than the surface soil and ranges in texture from a loam to a clay loam and in color from brown to reddish brown. It is slightly gritty, but becomes quite sticky when wet and hard and cloddy when dry. The subsoil is resistant. Roots penetrate the material with difficulty and the movement of water through it is slow. At depths between 18 and 30 inches the subsoil is underlain by a brown to reddish-brown impervious hardpan. This is of sandy texture and is underlain by a stratum similar in color to the subsoil, but of lighter average texture, more permeable, and consisting in most places of alternating beds of clay, silt, and gravel.

The Madera sandy loam is similar to the fine sandy loam except in texture, and ranges in depth from 10 to 20 inches. It is in places slightly micaceous and is normally underlain by a subsoil heavier in texture, more compact in structure and redder in color than the surface material. This in turn is for the most part underlain by a hardpan and substratum like those of the fine sandy loam. The distinctly heavier subsoil may not be present, the soil resting directly

on the hardpan, and in a few instances the hardpan is exposed at the surface.

The soils of this group are subject to more or less variation in color, texture, and structure. Some of the included material is of rather heavy fine sandy loam texture and approaches in character a loam and as mapped, may include locally some undifferentiated loam material. Small bodies of San Joaquin loam and sandy loam are mapped with the Madera group.

Location.—The Madera sandy loams group is confined to a few small scattered areas in the central and western parts of the survey. Those of the central part occur about the base of the mountain slopes in the vicinities of Pedley and Declezville west and northwest of Riverside, and as a single small body east of Riverside. These areas are mainly of sandy loam texture. The areas in the western part of the survey, most of which are of fine sandy loam texture, lie 3 or 4 miles north of Inglewood.

Topography and drainage.—A part of the group occupies level to irregular mesas and narrow ridges that occur between ravines cutting back into the old valley-filling deposits, but the greater proportion of the group occurs on smooth to gently sloping valley plains and old alluvial fans with but slightly irregular surfaces. Here a "hog wallow" topography similar to that of the San Joaquin series may exist. Sufficient relief exists to give most of the group good drainage, and there are no accumulations of alkali. The soils absorb water readily and when not too shallow they retain moisture fairly well.

Utilization and adaptation.—The Madera sandy loams group, mainly because of the small area, is unimportant agriculturally. The greater part of the land is used for the production of grain and grain hay and a small part is set in vineyards and orange groves. The topography and elevation unfit most of the areas for irrigation, and the yields vary largely with the character and depth of soil and the amount of precipitation. In normal years, on the typically developed areas, the yields are fairly good. The untilled areas which are covered with brush and a scant growth of grasses, are used for pasture. Most of the areas are near markets.

Antioch Series.

The Antioch series includes types with brown to dark-brown soils, underlain by a highly calcareous subsoil, in most cases lighter in color, heavier in texture, and more compact than the surface material. Variations show a light-brown to reddish-brown or grayish-brown soil. Lime concretions and streaks of grayish limy materials are not uncommon in the subsoil in this area. The surface is generaly smooth but in places marked by "hog wallows." As typically developed the soils are well drained, but in their occurrence in this survey there are

a few localities where drainage is deficient and where more or less alkali has accumulated. The series is distinguished from the Ramona series by its calcareous subsoil and the less definite geological origin of the parent material, though much of it has come from sedimentary formations. One group consisting mainly of the loam and clay loam is mapped.

ANTIOCH SOILS, UNDIFFERENTIATED.

Description.—The Antioch soils, undifferentiated, as mapped in this survey, consist mainly of the Antioch loam, the Antioch silty clay loam, and the Antioch clay adobe, small areas of Antioch sandy loam and fine sandy loam, and clay.

The Antioch loam is a brown to dark-brown, medium-textured loam from 14 to 30 inches deep. It is normally friable, contains moderate amounts of organic matter, absorbs water readily, and if properly cultivated retains it well. The soil is underlain by a brown, light grayish brown or yellowish-gray, heavy loam to a clay loam subsoil, which is more dense and compact than the surface soil and in most places distinctly calcareous. The brown material occurs where the lime content is low and gray or yellowish-gray material where the lime content is large. At a depth of 4 or 5 feet the subsoil merges into a stratum of brownish material which is less dense and compact than the upper subsoil and which in many places consists of silt and clay, stratified.

The Antioch silty clay loam is very similar to the Antioch loam in most features, and differs mainly in its heavier and more silty texture. It is smooth, friable, nonmicaceous, and more compact and more retentive of moisture than the loam.

The Antioch clay adobe is a dark-brown to dark grayish brown, medium to heavy clay, of adobe structure. It is extremely sticky and upon drying it cracks and checks profusely. It is moderately high in organic matter. It is tilled with difficulty unless moisture conditions are favorable and the fields tend to become cloddy. At a depth of 12 to 30 inches the soil is underlain by a grayish or grayish-brown subsoil, which ranges in texture from a silty clay loam to a clay. It is high in lime which appears as nodules, lenses, or seams in the heavy compact material. The subsoil is underlain by a substratum similar to the Antioch loam and the Antioch silty clay loam.

The Antioch sandy loam and fine sandy loam which are associated with the Antioch loam are similar to the loam type in color and general character, differing only in texture. They contain slightly less organic matter and are of more friable structure.

The Antioch clay is a brown to rather dark brown soil similar in essential features to the Antioch clay adobe, but lacking adobe structure. The type is inextensive and relatively unimportant in this survey.

The soils of this group are subject to more or less variation, but such departures from the typical are for the most part small in extent. Superficial deposits of recent alluvial material occur about the margins of some of the bodies, and some of the areas have a thin layer of wind-blown sand over the surface. In places gravel occurs in the subsoil. This is most common in the hilly and more broken to undulating and lighter textured areas.

Location.—The soils of this group are of little importance and are of small extent. The largest areas of the loam and silty clay loam lie several miles north and northwest of Corona. Small areas of various textures are around Hemet. The more important body of clay adobe occurs south of Fairview and several areas of the same type near the coast between Wintersburg and Huntington Beach.

Topography and drainage.—The topography in most places is flat to gently sloping, but here and there along the Santa Ana River, where erosion has been quite active, rather hilly and undulating areas have been developed. The more level and flat areas are marked by slight depressions and hummocks, and where the soils are heavy textured water usually stands in places during the wet season and more or less alkali has accumulated. In the more undulating parts of the types, where ravines and streams dissect the surface, the soils are free from alkali and have good drainage.

Utilization and adaptation.—The soils of this group are not so important agriculturally as many of the soils of the survey, and are mostly used for the production of grain, grain hay, beans, alfalfa, and sugar beets. Where dry farmed, grain, grain hay, and beans are grown with moderate to good yields. With irrigation sugar beets and alfalfa are grown successfully, except in the poorly drained areas with high concentrations of alkali. A few olives are grown on the silty clay loam type. The poorly drained areas and those parts less well adapted to cultivation are utilized for pasture. The areas are fairly well situated with respect to markets. Land values vary greatly, depending upon location, drainage, presence or absence of alkali, and availability of water for irrigation, and probably range from $60 to more than $200 an acre.

Las Flores Series.

The types included in the Las Flores series have light-gray to light brownish gray soils underlain at various depths by a gray to grayish-brown subsoil, in places mottled with yellow, heavier in texture, and much more compact than the surface soils. There is no hardpan or gravelly stratum in the subsoil, though it bakes hard and cracks when exposed to the air. The surface is slightly irregular or undulating to rolling, very uneven, and in many places marked by hummocks or "hog wallow" mounds and depressions. The soils of the series

usually occupy old eroded coastal plains, alluvial plains, or terraces, typically well drained. As occurring in this survey, however, the Las Flores soils, which are of small extent, depart somewhat from the typical development.[4] Here the soils are slightly micaceous, usually low lying and poorly drained, in many places puddled, and carry considerable quantities of alkali. Only one group of Las Flores soils, the loam and sandy loams, is mapped.

LAS FLORES LOAM AND SANDY LOAMS.

Description.—The Las Flores loam and sandy loams group consists chiefly of the loam, the sandy loam, and fine sandy loam types, with small areas of the clay loam of the series.

The Las Flores loam, the most extensive type in the group, is a medium to light textured loam, ranging in depth from 10 to 24 inches. When wet it is dark gray to dark brown in color and when dry light gray to gray. It is sufficiently level to bake and become quite compact and hard when dry. It is moderately low in organic matter, usually contains moderate amounts of lime, is slightly micaceous, and when given the proper care fairly retentive of moisture. The soil is typically underlain with a more dense and compact subsoil, which is generally, but not always, heavier in texture. It is usually darker in color than the soil, in places mottled, and in most places is high in calcareous material. When wet it is very sticky, but when dry, if exposed to the air, it becomes hard and assumes a dense and very refractory structure.

The sandy loam and fine sandy loam of this group are very much like the loam type, except they are of more sandy and lighter texture and absorb water more readily. Some of the more sandy areas have been modified slightly by wind action.

The soils of this group, while small in extent, depart from the typical in many places. Heavier phases of the loam and the clay loam are usually darker in color and have a more compact structure, which makes them more difficult to cultivate as well as less productive. In some areas the material is more micaceous and smoother in texture and browner in color than is typical of the Las Flores, and resembles the recent alluvial soils of the Hanford series, small areas of which may be included. In other places darker colored material of the Chino series is locally included. Variations also occur in drainage conditions and in alkali content.

Location.—The soils of this group are of small extent and unimportant in the agriculture. They occur in only a few areas. A long narrow area, mostly of light texture, lies near the Lakeview Mountains, another area, flat and poorly drained, east of Perris in the Perris Valley, and a smaller area a few miles west of Winchester.

[4] It is possible that this material should not be correlated with the Las Flores series and that with further examination and mapping in detail it may be recognized under some other series of soils.

Topography and drainage.—These soils represent old valley-filling material, typically occupying a position slightly higher than the adjacent recent alluvial soils, but more or less influenced by deficient drainage. The surface is prevailingly level to gently sloping, but marked with slight undulations, low hummocks, and small depressions. As a whole the drainage is very poor, and all of the areas are affected with alkali. In the lower and more depressed areas, water stands on the surface during certain periods, and a large part of the land is in poor physical condition as a result of puddling.

Utilization and adaptation.—Owing to poor drainage conditions and accumulation of alkali little use is made of the soils of this group. Some of the better drained parts are devoted to the production of grain and grain hay without irrigation, but most of the areas are in pasture. The yields of grain and hay are moderate. Artificial drainage and incorporation of organic matter would in most cases effect marked improvement in the soils.

Montezuma Series.

The soils of the Montezuma series are dark gray to black with variations of dark-brownish color. Under moist field conditions the prevailing color is black. The series is derived from weathered water-laid deposits, composed of materials having their origin in a variety of rocks. The subsoil is gray to brown. It is calcareous, with conspicuous nodules, concretions, or zones of lime concentration. The content of organic matter is in most places high. Their position is typical, being well elevated above the recent alluvial soils. The surface is sloping or undulating to rolling and the soils well drained, though retentive of moisture. They are represented in this survey by a single group of adobe soils. The soils of this series are differentiated from the Diablo series of similar color and appearance, on account of their derivation from unconsolidated rather than from consolidated rocks; and from the Dublin series, of recent alluvial origin, by their older character and resulting greater degree of weathering, greater elevation, and better drainage.

Montezuma adobe soils.

Description.—The group of Montezuma adobe soils consists of the clay adobe and the clay loam adobe of the series, of which the former is the more extensive and important.

The Montezuma clay adobe is a dark-gray to black, heavy textured clay, with pronounced adobe structure, ranging in depth from 18 to 36 inches. When wet it becomes extremely sticky, and upon drying, if not cultivated, it bakes and becomes hard and flinty, with the development of numerous deep cracks. As a whole, it is of refractory structure and careful management and heavy equipment are required to cultivate it properly. Under favorable conditions the soil assumes

a granular structure when cultivated. It absorbs water rather slowly unless in a granular condition, when run-off is checked and water finds its way into the deeper material through the cracks and crevices. When in such condition the soil has a large capacity for water and retains it well. If allowed to bake and become deeply checked, however, without formation of a protecting granular surface mulch, it loses moisture rapidly through evaporation. The soil is relatively high in organic matter. In places it contains small amounts of gritty material. The subsoil is compact, brown to gray in color, heavy in texture, and contains much lime. In many places lime occurs as conspicuous marly concentrations in seams, streaks, or pockets and as lenses and nodules. The substratum, usually extending to a depth of many feet is similar in most respects to the subsoil, but may consist of layers of clay, silt, and gravel.

The Montezuma clay loam adobe is very much like the clay adobe, except in its slightly lighter texture. The adobe structure normally is less pronounced, and as a whole the structure is more friable and the soil easier to till. It is slightly less sticky when wet than the clay adobe and absorbs water more readily. It apparently contains somewhat less organic matter than the heavier soil.

Some variations are noted in the soils of this group. These occur in most cases near the margin of the soil areas. In a few places the soil is brown, the subsoil contains little lime, and the type resembles the Ramona and Antioch soils, into which they merge in places. Near areas of recent alluvial soils, the group includes small areas of the Dublin clay loam and clay, while near the mountains the subsoil of a few areas differs from typical in containing quantities of gravel and being rather gritty.

Location.—The Montezuma adobe soils are most extensive in the western part of the survey near the coast. The largest area, consisting mainly of the clay adobe, extends from the southern part of Nigger Slough northwest to Inglewood. Smaller areas of the clay adobe are situated north of the San Pedro Hills, near Howard Summit, and north of Inglewood, while rather important bodies of the group occur southwest of Compton, southeast of Whittier, and in the vicinity of San Pedro. Other areas are mapped south of Hollywood, southeast of Santa Monica and near El Modena.

Topography and drainage.—The Montezuma adobe soils occur upon old coastal and alluvial valley plains, terraces, and alluvial fans. They occur at elevations somewhat above the recent alluvial soils. The material giving rise to the soils consists of these older water-laid deposits materially modified and altered in place by weathering, leaching, and concentration of lime. They are now undergoing degradation or removal by erosion. In general the topography is gently sloping to rolling, and in detail rather smooth to slightly un-

dulating. The areas are in places dissected by ravines and stream channels and as a whole they are well drained and free from alkali. In a few depressions where the soil is heavy and puddled, water stands on the surface during the wet season, and here there is more or less alkali. A few areas lying at somewhat lower elevations receive seepage from higher land and are poorly drained.

Utilization and adaptation.—The soils of the group are quite important agriculturally and practically all the areas are in cultivation. Grain, grain hay, beans and some truck crops are grown on a part of the types without irrigation. The yields are subject to considerable variation, but as a whole are moderately good in normal years. On other parts irrigation has been developed, and berries, alfalfa, truck crops, and some citrus and deciduous fruits are produced. Commercial and other fertilizers are used to a small extent for certain of the more intensively cultivated crops, but others are grown with little or no fertilizers and frequently without rotation. The soils are for the most part well located with respect to markets and public highways.

Mohave Series.

The soils of the Mohave series are derived from old valley-filling material which is apparently very old and has been subjected to long continued weathering and disintegration under arid desert conditions since deposition. The surface soil is pronounced reddish brown to yellowish red or red, but as mapped some areas of brown to grayish-brown material are included. The subsoil is usually redder in color and heavier in texture than the surface soil and is very compact. Both surface soil and subsoil are calcareous. In some places a hardpan varying in thickness is encountered at depths less than 6 feet, and in other places the subsoil is underlain by thick semicemented strata of gravel and bowlders consisting largely of igneous rocks. The topography varies from rather even and smooth to undulating or rolling and dissected. The series is confined to the desert region and occupies plains and old alluvial fans near the base of the mountains. It is well drained. The greater part of its area supports a desert vegetation. In this area the series is represented by the Mohave sandy loam and the Mohave loam and clay loam.

Mohave sandy loam.

Description.—The Mohave sandy loam is typically a light reddish brown to brownish-red soil which ranges in depth from 10 to 20 inches and is in texture a medium sandy loam. It is, however, as mapped in this survey, subject to quite a wide range in color variations and in depth and texture. Under moist field conditions the more typically developed areas are brownish red to pale red in color but when dry the brown or grayish-brown color is more pronounced and some

material of brown color in which the reddish tint is but slightly developed is included. This is the case particularly in the areas of the younger and less completely weathered material. In texture there is also a wide variation and the type includes, as mapped, material ranging from a light coarse sandy loam to a fine sandy loam and may include locally some small areas of loam texture. As a whole it is quite friable, easy to till, and is frequently very gritty. It is more compact and retentive of moisture than the Hesperia sandy loams, and like the other desert soils, it is very low in organic matter. It is usually underlain by a subsoil that is heavier in texture, more compact, and of more pronounced red tint than the surface soil, and which generally ranges in texture from a sticky sandy loam or loam to a clay loam. It frequently is quite high in calcareous material, and like the soil often contains coarse angular particles of quartz or other minerals and is gritty. When wet the subsoil has a tendency to be sticky and red in color and when exposed and dried in the open air it is inclined to cement and become hard and cloddy. At variable depths, usually from 3 to 4 feet, the subsoil normally becomes much grayer in color and contains large quantities of lime. At 6 feet or more it is underlain by a substratum of old, weathered, alluvial deposits, consisting of sands, silts, clays, and gravels which are quite variable in texture and arrangement, structure, color, and mineral composition.

All the areas north of the Cajon Pass and southwest of Hesperia, which are located on the higher elevations near the northern base of the San Gabriel Mountains, depart from the typical development of the type. They are not so red in color, are more friable, and are much more retentive of moisture than the soils east of the Mohave River, and as a whole they are not so gritty, contain more organic matter, are more easily tilled, and are more productive. The subsoil does not contain so much lime and does not vary so much in texture, as in the areas in the Apple Valley, and resembles very much the subsoil of the Ramona sandy loam. Iron-cemented red hardpan is present in parts of the area in Apple Valley, but it occurs intermittently at varying depths and is usually thin. This area is also subject to considerable variation in texture. In its eastern part the soil includes some reddish-brown heavy clay loam material, while in its western part a veneer of wind-blown sand covers the surface and is subject to more or less movement by the wind, so that a somewhat hummocky or undulating topography has resulted. The gravelly substratum, generally conspicuous in the Mohave loam and clay loams, is not generally so pronounced in this type.

Location.—The type is rather small in extent and occurs mainly as a single soil area east of the Mohave River in Apple Valley. Several important tracts also lie west and southwest of Hesperia near the base of the mountains.

Topography and drainage.—The Mohave sandy loam occupies steep to gently sloping old alluvial fans, old stream terraces, and eroded desert plains. These old valley-filling areas ordinarily lie at elevations considerably higher than the recent alluvial soils. Their surfaces are generally smooth to gently undulating, but in the regions near the base of the San Gabriel Mountains they are broken and dissected by numerous ravines and streams, which being deeply entrenched in the high fans, have produced a rather hilly or rolling topography in places. The type as a whole is well drained, and free from accumulations of alkali salts.

Utilization and adaptation.—A part of the type is used in a small way for agriculture, but like the other desert soils of the survey a large area is uncultivated at the present time and is of low value. The areas west and southwest of Hesperia, on account of their elevation and otherwise favorable situation, receive much more precipitation than the greater part of the desert, and consequently are better adapted to dry farming than the remainder of the type. Corn, grain, potatoes, and sorghum are grown here more or less successfully and several small deciduous fruit orchards have been planted and are growing without irrigation. In the western parts of the area in Apple Valley, some water is pumped for irrigation and several apple orchards have been planted and alfalfa is grown successfully. The area irrigated at the present time is small, but means of developing additional facilities for irrigation are being considered, and if this can be accomplished greatly increased production will result. A part of the area in this region is dry farmed to grains, but with rather discouraging results, as the yields are always very low and failures quite frequent. The type is fairly well supplied with roads, considering that it lies in an undeveloped desert region. Land values depend on numerous factors, such as location, variation in character of soil, irrigation, and improvements.

MOHAVE LOAM AND CLAY LOAM.

Description.—The Mohave loam and clay loam group includes the loam and clay loam types of the series, with a few small areas of the clay.

The Mohave loam, which is the most extensive type, is a light reddish brown to red, medium to heavy textured loam, ranging in depth from 12 to 24 inches. It is low in organic matter, has a moderately compact structure, is normally gritty, and in most instances is rather hard to till. The subsoil generally consists of a heavy clay loam or clay which is of a much more compact, dense structure and of redder color than the surface soil, and is difficultly permeable by water. When wet it is quite sticky, and when exposed to the air it has a tendency to cement and become quite hard upon drying. In places it contains considerable quantities of calcareous material and more

or less fragmental rock. At depths, in most cases less than 6 feet, the subsoil is typically underlain by partially cemented or compact gravelly and stony stratum, the rock consisting largely of igneous formations. This substratum varies greatly in thickness and is not everywhere continuous. Below this substratum the material is variable in color, structure, and texture, and in many places consists of stratified deposits of clay, silt, gravel and sand extending to undetermined depths.

The Mohave clay loam and clay are very similar to the loam type except for their heavier texture. Also the topography of these heavier types is in many cases more undulating and broken than that of the lighter types and as a whole they vary more in color. They are naturally more compact and more inclined to bake and become hard when dry if not cultivated. Tillage is ordinarily difficult, and the few areas under cultivation are more or less cloddy.

The group is subject to considerable variation and includes soils that could not be effectively separated in a reconnoissance survey. In a few places the areas have a covering of wind-blown sand which ranges in depth from a few inches to several feet. The topography in such cases is more or less undulating or hummocky. Small areas contain considerable quantities of bowlders and cobblestones, which gives them a lower agricultural value than the typical areas. Other variations in color and structure occur, but they are relatively unimportant and are confined to small areas.

Location.—This group of soils occurs in the Mohave Desert, in the northern part of the survey. The most typical body, and one of the largest, lies west of the Mohave River and north of Hesperia. Small scattered areas also occur in the hilly regions south of Hesperia, north of the West Fork of the Mohave River. Several areas are found northwest and northeast of Valyermo, in the Holcomb Valley, near Baldwin Lake, and east of Tiptop Mountain. The areas mapped north of Acton are subjected to considerable variation in texture. Here in many places bedrock is near the surface and some residual soils may be included.

Topography and drainage.—This group of soils occupies desert plains, old alluvial fans, and terraces of old valley-filling material. The topography is undulating to broken. They have been eroded by former streams which now carry little or no water. Their channels and laterals have rounded bottoms and their banks, quite steep, are weathered and disintegrated, and seldom show fresh exposures of the original deposits. Generally the heavier textured types are more broken and eroded than the loam and sandy loam. On account of low rainfall, drainage is not an important factor, yet the topography is such that the types in most places would be well drained even with a heavy precipitation.

Utilization and adaptation.—A very small area of these soils is used for agriculture mainly because of unfavorable climatic conditions and lack of means of irrigation. The heavy texture, compact structure and eroded or irregular topography are also rather unfavorable and adjacent areas of soils of smoother surface and lighter texture will probably be developed first. In the vicinity of Valyermo, near the mountains, where the precipitation is higher, some dry farming has been attempted and a few areas have been planted to apples and pears. There is very little of the soils in this locality. In the Acton district small acreages of grain and other dry-farmed crops are planted, but with indifferent results. Most of the area of the group is uncleared and supports a vegetation typical of the desert.

Hesperia Series.

The soils of the Hesperia series consist of old alluvial deposits which appear to have undergone less complete weathering and alteration than the associated soils of the Mohave series. Considerable oxidation has occurred, but the soil has remained rather uniform throughout the profile, there being in many places very little apparent difference between soil and subsoil material, though in general the subsoil is slightly redder, a little heavier in texture, and more compact than the surface soil. The surface soil is typically brown, with grayish-brown to reddish-brown variations. Small angular to subangular particles of quartz or granite occur in the soil and subsoil making it gritty. A thin veneer of light textured material, subject to drifting, covers some areas. The surface is gently sloping and for the most part smooth and even. The soils, like the Mohave series, are confined to the desert and occupy desert plains and alluvial fans. Both soil and subsoil material are usually calcareous. They support a growth of desert vegetation. In this survey the series is represented by the Hesperia stony sandy loam, and the Hesperia sandy loams.

Hesperia stony sandy loam.

Description.—The Hesperia stony sandy loam is a light-brown or brown to slightly reddish brown soil, ranging in texture from a light to a medium sandy loam and carrying many bowlders and stones. The bowlders, some of them over 6 feet in diameter and only slightly rounded, cover the surface, and occur in varying numbers through the soil mass, but in most instances are sufficiently numerous to render the type practically worthless for agriculture, even if all other features were favorable. The soil ranges in depth from about 12 to 36 inches, contains large quantities of gritty material, and is of a very loose structure to a depth of three to four inches in depth where it becomes moderately compact. The subsoil is slightly more compact, a little heavier in texture than the surface soil, and light

brown to reddish brown in color, but the distinction between the soil and subsoil is very indefinite as one gradually merges into the other and the two are very similar in most features. Like the surface soil, the subsoil also contains many stones of igneous formation, which in places are now partially weathered and disintegrated. It continues to a depth of many feet.

Location.—The type is very small in extent, occurring only in two areas, both in the Mohave Desert.

Topography and drainage.—The type occupies rather steep alluvial fans which have been eroded deeply by numerous intermittent streams from the mountains.

Utilization and adaptation.—The type is not cropped except in one or two very small gardens which are irrigated. For reasons stated it is not likely that the type will be of value, except as grazing land, and even for this purpose the value will be low.

HESPERIA SANDY LOAMS.

The Hesperia sandy loams group consists mainly of the sandy loam and the fine sandy loam types of the series, although small areas of the sand and fine sand occur. The sandy loam has the greatest extent and is the most important of the types included.

Description.—The surface soil of the Hesperia sandy loam is a light-brown or brown to slightly reddish brown coarse to medium textured sandy loam. The soil is gritty and has a loose porous structure, the upper 3 or 4 inches being so extremely incoherent that the material is drifted by the wind. It is very low in organic matter, but is easily tilled. It absorbs water readily but holds it poorly. While it may contain small amounts of lime this constituent is neither so prevalent nor so concentrated as in the Mohave series. At varying depths ranging from 12 to 40 inches, the soil gradually merges into the subsoil. This in many places is very similar to the surface soil, but for the most part it consists of a brown to reddish-brown medium to heavy sandy loam, containing enough clay to cause stickiness when wet, and a hard and cloddy condition when dry. It is gritty, and contains small amounts of lime in places. In places the subsoil is underlain at varying depths by stratified material consisting of silt, sand and gravel.

The Hesperia fine sandy loam is rather similar in most characteristics to the sandy loam type, differing mainly in its somewhat finer and smoother, less gritty texture. Typically it is slightly more compact than the sandy loam, appears to be of more recent origin, and is slightly micaceous. It is also not quite so red in color as the lighter textured soil. In the matter of retention of moisture it is a somewhat better soil.

The Hesperia sand and fine sand material commonly occur within the areas of Hesperia sandy loam or are confined to the same general

localities. It is very similar in color and subsoil features to the types already described. It is frequently more gritty than the heavier types and has a looser structure and the surface has been more or less modified by wind and resembles that of the Oakley series, a true wind-laid series. Among the variations noted in mapping this series are areas of yellowish-brown color in the sand and sandy loam types and deposits of white to gray flourlike material, highly calcareous, occurring as a surface layer in parts of these types. Near the northern boundary of the survey northwest of Hesperia, the areas include soils belonging to the Mohave series. The topography of this part of the type is somewhat uneven and along the banks of the streamways the subsoil appears to be heavier in texture than in the smoother areas of the more typical bodies. In the northeastern part of the survey the group includes small bodies of Rough broken and stony land and areas that are more or less stony and carry excessive quantities of very small angular gravel, which makes the soil very gritty. In this locality, near some of the isolated mountains and buttes, the bedrock is often near the surface and in some instances small bodies of the residual soils may have been included.

Location.—The Hesperia sandy loams are confined to the Mohave Desert. They are most extensive in the region west of Hesperia and in the section extending east from Apple Valley. A small body occurs where Sheep Creek enters the desert from the San Gabriel Mountains, and there are two small tracts about 4 miles northwest of Valyermo. A few areas, very sandy and with a more or less undulating topography are developed in the vicinity of Vincent in the northwestern part of the survey. Areas of fine sandy loam and sand textures are most prominent east of the Box S Ranch, southeast of Fifteenmile Point, and in the section 3 or 4 miles west of Means Wells. Bodies of the sand also occur in the vicinity of Johnson Valley, in the southern portion of Lucerne Valley, and in the western part of the area about Hesperia.

Topography and drainage.—The soils of the group occupy gently sloping plains, alluvial fans, and colluvial slopes near the base of some of the isolated mountains and buttes. They are derived from rather old deposits that have been very little changed by weathering and disintegration. The surface for the most part is smooth and even, but is in places, especially west of Hesperia, eroded or traversed by old drainage ways, which now seldom carry water, but which have entrenched themselves rather deeply in the regions near the mountains. The channels have rounded bottoms and well weathered banks, and as they continue on into the desert decrease in depth until they disappear and merge into the smooth, gently sloping topography typical of the Hesperia soils. The areas are well drained. The surface is in most places well suited for irrigation.

Utilization and adaptation.—Very little of these soils is utilized on account of the low precipitation, which will hardly permit of dry farming, and of the present lack of water for irrigation purposes. In the areas west of Hesperia the greater proportion of the group has been homesteaded, and the settlers have attempted the growing of dry-farmed crops, but in many cases they have met with indifferent success and many of them have now moved away. The principal crops attempted without irrigation are barley, wheat, corn, and milo maize and other grain sorghums. Some of these can be successfully produced in favorable years. East of the Box S Ranch practically no settlement has been made on this group of soils. The typical desert vegetation, including juniper, rabbit bush, and yucca or "Joshua Tree," and various desert shrubs cover the greater part of the group, and it is used very little for grazing. (Pl. IV, fig. 1.) Roads, sometimes sandy, but fairly good for the desert, reach most of the bodies. Hesperia and Victorville, the latter just outside of the area surveyed, are the nearest railroad points for most of these types.

Lahontan Series.

The types included in the Lahontan series have light-gray to brownish-gray soils, a light-gray to slightly yellowish gray subsoil. The subsoil is variable in texture, with a tendency in many of the lighter types to be somewhat heavier than the soil. Both soil and subsoil are calcareous. The surface is flat or level to gently sloping, and for the most part smooth. In a few places it is modified by drifted materials, by ancient terraces and beaches, or by deeply cut stream channels. Drainage is moderately well developed except in the depressions occupied by playa flats which contain shallow lakes after heavy rains, or where they collect seepage water from irrigation. More or less alkali is present, especially in the poorly drained areas.

The Lahontan series is derived from lake-laid sediments, but as mapped in this survey is not typically developed, the areas representing only the lower lying parts of such deposits. One group of this series of clay loams and clays is shown on the accompanying map.

Lahontan clay loams and clays.

Description.—The Lahontan group of soils includes mainly the Lahontan clay loam and the Lahontan clay, with some small areas of silty clay loam and silty clay texture. As occurring in this survey these types are not typical Lahontan, as they lack the substratum of deep lake-laid deposits found in the series where typically developed. The soils here are regarded as phase variations of the Lahontan, and in subsequent detailed surveys may be recognized as belonging in a distinct series.

The Lahontan clay loam is a light grayish brown or gray to brownish silty clay loam to a heavy clay loam, with a depth of 10 to 24

inches. It is low in organic matter, is very compact, and contains moderate amounts of lime. When wet it is very sticky and upon drying becomes very hard and cracks. A relatively large proportion of coarse angular sand is mixed with the finer particles in many places. The soil is commonly in a puddled condition, and does not absorb water readily. It is tilled with difficulty. The subsoil is variable in texture, being in some places heavier and some places lighter than the soil. In many areas it is stratified, the layers ranging from silt to sandy gravel. Ordinarily its color is grayer than that of the surface soil. It is highly calcareous and may contain thin layers of very light gray or white partially cemented limy material which becomes very hard when exposed to the air. The substratum is in many places similar to the subsoil, consisting of silt and clay or gravel and sand strata that extend to a depth of many feet.

The Lahontan clay is similar to the Lahontan clay loam, except it is much heavier in texture and more compact in structure. It usually occupies low depressions of poor drainage and ordinarily is badly puddled. Deep and wide mud cracks develop as the soil dries. It is of more unfavorable structure than the clay loam and is always more or less cloddy when tilled.

The soils of the group are subject to numerous variations in texture and color and in transition zones include areas in which the Lahontan materials have been covered up by materials of the Mohave and Hesperia series. These variations are usually browner in color, less compact, and more productive than the average Lahontan areas. The structure is subject to much variation, parts of it having much better drainage than other parts.

Location.—The group of soils covers a small area in parts of the Mohave Desert east of the Mohave River. The largest area occurs in Lucerne Valley north of the Box S Ranch, and smaller areas lie east of Fifteenmile Point, east of Deadman Point, and in the Johnson Valley.

Topography and drainage.—The soils of this group occupy very gentle slopes and flat depressions with rather even smooth surfaces which occur at slightly lower elevations than the adjoining Hesperia and Mohave soils. They occur mainly upon the bottoms of playa lakes, a common feature of the desert, which serve as collecting basins for the small amounts of surplus water. In many places parts of these areas are covered with thin sheets of muddy water for periods of a few days to several weeks after storms. The drainage is thus very poor, and large quantities of alkali have accumulated in most places. North and northeast of the Box S Ranch along the margin of the survey the drainage is better than elsewhere, the structure of the soil is better, and the concentrations of alkali are lower.

Utilization and adaptation.—The soils of this group are unimportant; only a very small proportion of their area is used for cultivated crops. The playas which are occasionally covered with water support no vegetation. Around their margins and on the better drained areas a scant growth of desert shrubs occurs. These have a very little value for grazing. On the better parts of the group in Lucerne Valley some alfalfa and deciduous fruits give fair results with irrigation. Roads reaching the areas except those east of the Box S Ranch, which are very sandy and quite heavy for travel, are moderately good for the desert. The group as a whole is also far removed from markets and the railroad.

RECENT ALLUVIAL SOILS.

Tujunga Series.

The soils of the Tujunga series are gray to brownish gray with variations of grayish brown. The subsoil is in most places uniform in color, texture, and in other characteristics to the depth of 6 or more feet. The series occupies sloping alluvial fans and stream bottoms and has a smooth, even, surface, except in some of the lighter types where it has been modified by erosion or drifting. The materials giving this series have been washed mainly from areas of granitic formations. They are in most places well drained and free from alkali. Four groups of types were recognized and mapped as belonging to this series. The series is closely related to and associated with the Hanford series of soils from which it is differentiated by its lighter shade of color.

TUJUNGA STONY SANDS AND STONY SANDY LOAMS.

Description.—The group Tujunga stony sands and stony sandy loams includes the stony coarse sand, stony sand, stony fine sand, stony coarse sandy loam, stony sandy loam, and stony fine sandy loam of the Tujunga series.

The Tujunga stony coarse sand is a coarse gritty sand of light-gray to light brownish gray color. The material, which contains little organic matter, is loose and porous in structure and only slightly retentive of moisture. The surface material may extend to the depth of 6 feet or more without change, or a subsoil may occur consisting of imperfectly assorted sands and gravel. Both soil and subsoil usually contain an abundance of gravel, cobbles, and bowlders. These are derived mainly from granitic rocks or from gneisses or schists. The fragments vary from well-rounded to subangular in shape and from mere pebbles to pieces several feet in diameter. They usually increase in size and angularity with the steepness of the fans upon which they occur and as the mountain canyons from which they emerge are approached. The material is not consistently

calcareous, though under the more extreme desert conditions occurring in parts of the survey there is a tendency toward this condition through deficient rainfall and consequent lack of leaching away of the salts liberated in the weathering of the soil material.

The Tujunga stony sand, which with the Tujunga stony coarse sand forms the greater proportion of the area of the group, is a light-gray to light brownish gray sand incoherent and gritty. It is deficient in organic matter and leachy. It contains gravel and stones similar in amount and character to those occurring in the Tujunga stony coarse sand. The subsoil material is for the most part similar to the surface material, but may include pockets or strata of either coarser or finer sandy and stony material. The soil and subsoil material is generally poorly assorted, the profile exhibiting imperfect stratification. The material is micaceous and typically not calcareous. The stone content is in many areas extremely high, the sandy material forming merely the interstitial filling between the bowlders and cobblestones.

The Tujunga stony fine sand, which is inextensive, is slightly browner than the types just described. The finer texture makes it more retentive of moisture than the coarser types but is otherwise quite similar.

The Tujunga stony coarse sandy loam is a coarse, gritty sandy loam of light color and high stone content. In subsoil and general features it is similar to the Tujunga stony coarse sand but its larger proportion of fine soil material makes it more retentive of moisture.

The Tujunga stony sandy loam and stony fine sandy loam are typical of the series. They contain more organic matter than the coarser types and have a more pronounced brownish color. They have a somewhat higher power of retaining moisture, but the stone content is generally moderate to excessive and the soils not well adapted to agriculture except under irrigation.

Location.—The areas of this group are widely distributed but occur mainly in the central part of the survey. In the western part they are confined to small narrow areas along the Tujunga River. The areas lie upon the alluvial fans of these streams, and also occupy their narrow, gorge-like valleys well within the San Gabriel Mountains. In the central part of the survey they occur as narrow bodies along Lytle Creek, Cajon Canyon, and other streams issuing from the San Gabriel Mountains between Pasadena and San Bernardino. The most extensive and uniform body in this region occupies the higher part of the San Antonio fan, which extends north from Claremont. In the east-central part of the survey the soils of this group are extensively developed on the fan of the Santa Ana River, below its canyon north of Riverside, and in the San Gorgonio Pass and Coachella Valley. They also occupy most of Lone Pine Canyon and

Swartout Valley in the San Gabriel Mountains, with an area extending from the latter down Sheep Creek into the Mohave Desert. Nearly all of these bodies include flood-swept areas of barren character which in a more detailed survey would be mapped as River-wash. In the Lone Pine Canyon, Sheep Creek, and Swartout Valley districts the material is of rather dark color, being derived from dark-colored schists and similar rocks, and is not typical of the Tujunga series. There also these soils approach in climatic conditions those of the Mohave Desert, and in the Coachella Valley true desert conditions are attained. In the latter localities the material is probably more or less calcareous and it is possible that the soils will in future detailed surveys be included wholly or in part in distinct series of desert soils.

Topography and drainage.—The larger and typically developed areas of these soils occupy extensive alluvial fans of uniform slope debouching from mountain canyons and spreading outward with gradually decreasing gradient to the lower and flatter slopes of the valleys. The upper parts of the fans may be steep and gullied by wide shallow stream courses which branch and subdivide lower down on the fan slopes and form a system of poorly defined distributaries which frequently lose themselves and disappear entirely before the lower margins of the fans are reached. The slope upon the steeper part of the fans frequently ranges from 100 to 300 feet to the mile. While the general topography is smooth and uniform, the surface in detail is irregular, in many places being eroded and marked by ridges and heaps of stones. The cost of removing the stones and smoothing out slight irregularities of the surface in preparing the land for irrigation is considerable, but the general slope favors the distribution of water when the land has been thus prepared. Some of the streams carry water in the vicinity of the canyon mouths during much or all of the year, but little of the water finds its way by natural means to the lower part of the fans during summer. Parts of the areas near the stream channels are subject to torrential floods at times during rainy seasons, though they may not occur in any one locality during periods of several years. The areas occupying canyon valleys include stream bottoms, low stream terraces, and a complex of local alluvial fan slopes built by small lateral tributaries. Both surface and subsurface drainage are excessive. Much of the coarser material has been rolled to its present position and the shallow winding waterways soon become choked with débris and force the flood waters to seek new channels.

Utilization.—The soils of this group usually support in their native condition a desert-like vegetation, consisting of ceanothus and other brushy shrubs, yucca, cacti, and other plants. A few willow and cottonwood trees occur in permanently moist situations along stream

channels. But little of the land has been cleared and most of it is poorly supplied with roads and is relatively inaccessible. It is used mainly for grazing. Expense of clearing, porous leachy character, and lack of water for irrigation are the factors preventing more general use for agriculture. Local areas of a few acres favorably situated for irrigation from the small streams are in various crops and small areas in the more favorably situated bodies have recently been planted in citrus fruits, but the returns are small. With further increase in population and the extension of means for irrigation, agriculture which has been developed upon adjacent types may encroach somewhat further upon the types of this group.

TUJUNGA GRAVELLY SANDS AND GRAVELLY SANDY LOAMS.

Description.—This group of soils is associated with the Tujunga stony sands and stony sandy loams and is quite similar to that group of soils in manner of occurrence. It includes the gravelly coarse sand, gravelly sand, gravelly fine sand, gravelly coarse sandy loam, gravelly sandy loam, and gravelly fine sandy loam. These soils merge with the stony types of the series, and in many places contain some cobblestones and bowlders, so that boundaries separating the gravelly from the stony types are more or less indefinite and more or less arbitrarily placed in the soil map. The soil and subsoil material in most places contain enough gravel to affect cultivation and the movement of soil water.

The interstitial soil material of these types is of light-gray to light brownish gray, or light grayish brown color and is similar to that of the corresponding stony types. The gravel ranges in size from fine pebbles to coarse gravel and cobblestones, and consists predominantly of granitic rocks. The soils are low in organic matter, are of loose porous structure, and generally low in water-holding power. The materials are typically micaceous but not calcareous.

Some areas of the stony group of the series and of Riverwash are included with the gravelly group. Some of the material occurring in the extreme eastern part of the survey may in later detailed surveys be classed as a distinct series of desert soils. Of the types represented in the group the gravelly sand and the gravelly sandy loam predominate, the others being of small extent and occurring in poorly defined areas.

Location.—The soils of this group occur in widely separated regions, but are of only moderate extent. The principal areas are in the San Fernando Valley, where they are associated with the alluvial fans of the Tujunga River and Pacoima Wash; in the vicinity of Etiwanda in the central part of the survey; north of Redlands, and in the San Gorgonio Pass and Coachella Valley. Small areas lie

along Lytle Creek, and in the vicinity of the Santa Ana River and the town of Highlands.

Topography and drainage.—In topography and drainage the soils resemble the stony types of the Tujunga series of corresponding texture, but the slopes of the alluvial fans upon which they occur are usually somewhat less steep, and the stream channels and other irregularities of surface are less pronounced. Frequently dividing stream channels occur. Some of these carry water during flood periods, and during unusual floods parts of the areas are subject to overflow, erosion, and deposition of sand, gravel, and bowlders. Surface drainage is good and subdrainage is excessive. The types of this group are slightly less leachy than those of the stony types, but their moisture retaining capacity is low and irrigation is necessary to their development for agriculture. The native vegetation consists mainly of species of desert shrubs, yucca, and cacti. The surface is generally uniform and well adapted to distribution of water where irrigation is possible.

Utilization.—Most of the land of this group is undeveloped and used only for grazing. Dry farmed grain and grain hay are grown to some extent. In the San Fernando Valley small acreages are devoted to the production of grapes, alfalfa, and tree fruits. Fair results are obtained on the soil types of finer texture. In the Etiwanda district a part of the extensive planting to wine grapes is upon the soils of this group. Small areas have been set in peaches, almonds, and apricots. In the eastern part of the survey the soils are somewhat coarser in texture, the rainfall is less, and development is hampered by lack of water for irrigation. Oranges are grown upon small parts of the areas that are irrigated, but the areas in the San Gorgonio Pass and in the Coachella Valley are, except in a few cases, unirrigated and used only for pasture. In value and productiveness the soils of this group probably average slightly above the Tujunga stony sands and stony sandy loams.

TUJUNGA SANDS.

Description.—The group Tujunga sands includes the Tujunga sand and the Tujunga fine sand.

The Tujunga sand consists of a light-gray to gray, relatively coarse to medium textured sharp and gritty sand, consisting mainly of quartz, but with some feldspar, mica, and other minerals. The soil contains little organic matter, is loose and porous and holds moisture poorly. Gravel and bowlders may occur, but generally the quantity is small except in local areas, which in a detail survey would be separated as the Tujunga gravelly and stony sands and sandy loams. The subsoil may be similar to the surface soil or it may be formed of stratified or imperfectly stratified material consisting of pockets of

sand and gravel. Both soil and subsoil are micaceous and free from hardpan or other impervious layers. Characteristically the soils are not calcareous.

The Tujunga fine sand is not only finer in texture than the sand, but the particles are in general more rounded and the feel less gritty. The fine sand also contains more organic matter and the soil is browner, and brown variations that approach the color of the Hanford soils are more numerous. The material is porous and permeable to moisture, but its ability to absorb and retain moisture is greater than in the sand. The subsoil, which is variable, consists of alternating strata of stream-laid materials ranging from coarse sand to silt. On the whole the subsoil is finer or slightly more compact than the surface soil. In places beds of gravel are also encountered in the subsoil. In general the texture of both surface and subsoil averages finer on the lower slopes than higher up on the fans on which they occur.

Tujunga sands in places occur as small strips or belts or irregular bodies in intimate association with each other or with types of other series. Where this is the case they can be separated from each other only with difficulty and small areas of soils of the Hanford or of other series have doubtless been included.

Location.—Conspicuous areas of the soils of this group lie in the eastern part of the San Fernando Valley, north and northwest of Los Angeles, extending southward from Los Angeles nearly to San Pedro Bay, and on the Cucamonga Plain in the central part of the survey. Small bodies occur along San Gabriel Wash and Lytle Creek, and in the vicinity of Harlem Springs, and along the Santa Ana River between Colton and Rincon.

Topography and drainage.—The surface is generally regular and gently sloping, with some interruptions where streams have eroded the surface and minor irregularities consisting of low hummocks of wind-blown soil. The latter are most noticeable about clumps of bushes and weeds in uncultivated areas and along hedgerows and fences. The stream courses range from shallow, sloping drainage ways to deeper channels with perpendicular banks. Parts of the type in the western part of the survey occupy low positions along streams or washes or lie in abandoned stream channels. The lower lying areas adjacent to the streams are subject to overflow and in some places have a high water table. The greater part of the group is, however, less frequently or regularly flooded and is excessively drained, owing to the porous character and rapid subdrainage. Some of the areas are subject to occasional destructive floods caused by unusually heavy rains, the accumulated run-off being discharged across the fans from mountain canyons. Such torrential floods may last but a few hours and occur but once in a period of several years,

but serious injury to crops and to the land through erosion or the deposition of material sometimes occurs. The soils of the group do not contain alkali in injurious quantities.

Utilization.—The soils of this group vary greatly in use and in value. In their native condition the higher areas normally support a growth of low shrubs, yucca, or other desert plants. Some of the areas near stream channels bear a growth of willow and cottonwood, and others remote from streams are nearly barren and of little agricultural importance. In other localities the soils are intensely cultivated and of high value. In the San Fernando Valley and in the Cucamonga district the land is extensively used in the production of deciduous stone fruits, alfalfa, and truck crops, both with and without irrigation. Grapes also are grown and constitute the most important product on these soils in the Cucamonga district. Peaches are also a very important crop in both the San Fernando Valley and on the Cucamonga Plain. A large part of the product is utilized in local canneries. Apricots are also an important crop and alfalfa and grains are grown to some extent. Grapes are generally grown without irrigation or fertilizers, but stable manure is used to some extent on orchard crops and irrigation is practiced in the growing of alfalfa and part of the orchard fruits. In the areas in the vicinity of and south of Los Angeles potatoes and truck crops are the principal products.

TUJUNGA SANDY LOAMS.

Description.—The Tujunga sandy loams group includes the sandy loam, and the fine sandy loam of the series. Minor variations in color and texture are included and local areas of gravelly or stony character occur but the soils do not carry excessive quantities of stones or gravel.

The Tujunga sandy loam is a light brownish gray to gray or light grayish brown,[5] micaceous sandy loam of open porous character. It is low in organic matter. The subsoil is in most places similar to the surface soil and without distinct differentiation in the soil profile, except in the lower part, where minor pockets or layers of gravel or other stratified material may occur. Both soil and subsoil are permeable and have no marked capacity for storing water, though under favorable conditions of tillage they hold moisture well considering their texture and structure. Neither the surface nor subsoil material are typically calcareous.

The Tujunga fine sandy loam is a light-gray to light brownish gray fine sandy loam, with brownish variations a little better developed than in the sandy loam.[6] The material is usually distinctly micaceous

[5] The brownish tint is most pronounced where the soil grades into the Hanford.

[6] Separation from the Hanford series on the basis of color is difficult and, as mapped, the material may include some undifferentiated Hanford material.

of porous, friable structure, and low in organic matter. The subsoil material is nearly everywhere similar to the surface soil, but variations, containing stratified layers or pockets of sandy material of coarser texture and in places gravel, occur. The type is easily cultivated and, under favorable conditions of moisture and culture, is productive. On the average it is somewhat more absorptive and retentive of moisture than the sandy loam.

Location.—This group of soils occurs in quite extensive areas, principally in the San Fernando Valley in the western part, and in the east-central part of the survey. The areas in the San Fernando Valley occur mainly in the vicinity of and west and northwest of Burbank. Those in the San Bernardino Valley lie in the vicinities of San Bernardino, Riverside, Redlands, and Highlands.

Topography and drainage.—The types of this group of soils occupy the flatter lower parts of the alluvial fans composed of soils of the Tujunga series. The surface is generally smooth and gently sloping to nearly level, cut here and there by the poorly defined courses of shallow drainage ways. These are dry during the greater part of the year, but carry water during brief and infrequent periods following heavy rains in the mountains. During periods parts of the areas are overflowed. Some of the lower lying bodies along the Santa Ana River and other large streams are also overflowed during high stages of these streams. Run-off is generally free and subdrainage rapid and complete, and over much of the area drainage is excessive. The surface is favorable for irrigation. Except in some of the lower-lying areas situated along the larger streams, the water table lies at considerable depth.

Utilization.—The Tujunga sandy loams constitute the most extensively utilized and highly developed soils of the Tujunga series. They are devoted to a variety of crops, including grain, grain hay, alfalfa, grapes, oranges, truck crops, peaches, apricots, sugar beets, walnuts, prunes, pears, and sweet potatoes. Irrigation is practiced extensively, water being supplied by gravity systems and by pumping from underground sources, but parts of the areas are utilized for grain and hay crops, grapes, peaches and apricots without irrigation. Irrigation is advisable where a water supply exists.

The soils are generally well located with reference to improved highways, cities and towns, shipping points, and railways.

Hanford Series.

The types classified in the Hanford series are brown or light-brown to grayish-brown, recent alluvial soils, derived principally from materials washed from areas of granite, gneiss, and schist. The soil in many places extends to 6 feet or more without appreciable change in the texture. The subsoil varies widely, and may be either lighter or

heavier than the surface or consist of alternating layers of variably textured sediments. The color is similar to or slightly lighter than the surface soils. The soils occupy alluvial fans, stream bottoms (Pl. IV, fig. 2), and low recent terraces, with moderately smooth and even level to gently sloping surfaces, except in case of some of the fans that are quite steep and stony. As a whole the soils are well drained but parts are subject to overflow or a high water table, and the accumulation of alkali. The Hanford soils are distinguished from the Tujunga by their darker and browner color, and from the Cajon series in being noncalcareous, and from the Yolo series by the presence of mica which indicates difference in origin. In this survey one individual type and five type groups are mapped.

HANFORD SANDS.

The Hanford sands group includes the sand, fine sand, coarse sand, and gravelly sand of the series. Of these the Hanford sand and the Hanford gravelly sand predominate, the associated types being of small extent and importance.

Description.—The Hanford sand is a brown to grayish-brown soil ranging in texture from a relatively fine to a medium or somewhat coarse textured or stony sand. This may extend to a depth of 6 feet or more without change, or as is the case in many instances, change in the lower part of the soil profile to a lighter or heavier material of slightly gray color. In numerous places this lower material consists of alternating beds of stratified material. The soil is very micaceous, for the most part gritty, and low in organic matter. It has an open, porous structure and absorbs water very quickly. Considering the texture it is also moderately retentive of moisture if properly handled.

The Hanford fine sand is of finer, smoother texture, more compact, and of somewhat greater capacity for moisture than the sand. It requires less water in irrigation and is as a whole more productive.

The Hanford coarse sand is of somewhat lighter grayish brown color, is of coarser gritty texture, is more loose in structure, and contains less organic matter than the fine sand and sand types. Its power to retain moisture is low and it is inclined to be droughty. It occurs mainly as narrow strips along old stream channels or on some of the alluvial fans.

The fine material of the Hanford gravelly sand is of relatively sandy to coarse texture and in essential features is similar to the Hanford sand. It is, however, for the most part very gravelly and in a few of the areas the soil is quite stony. The gravelly and stony soils of the group occur mainly on the upper parts of the alluvial fans. The coarse material is usually sufficient to interfere more or less with cultivation and soil moisture is somewhat less easily retained.

In certain situations the subsoil of this soil group contains considerable fine material, is quite loamy, and is more retentive of mois-

ture than the average. In others the bodies include areas of old valley-filling soils, or heavier textured recent alluvial soils, which have been blanketed with a deposit of Hanford material having a depth of 3 to 5 feet. Small undifferentiated bodies of Hanford fine sandy loam, as well as of Tujunga sands and Riverwash were included with the group.

Location.—The soils of this group are most extensive north of the Jurupa Mountains between Rialto and Etiwanda, and in the region east of Chino and Ontario. A large area lies west of Azusa and a number of small narrow areas occur along the San Gabriel River. Along the Santa Ana and Los Angeles Rivers in the coast regions, and in the vicinity of Los Alamitos, as well as on some of the rather steep fans north of San Fernando are smaller areas intermingled with other Hanford types. Long, comparatively narrow bodies, including some areas of Riverwash lie along the Mohave and Santa Clara Rivers.

Topography and drainage.—The soils of this group, which is of recent alluvial origin, occupy gently sloping to rather steep fans, and slightly undulating stream flood plains and stream deltas. In many places they are situated in stream channels and on stream-built ridges which commonly rise slightly above the adjoining recent alluvial soils. The surfaces are generally fairly smooth and even, in most places suitable for irrigation without much leveling. In a few places, however, the surface of the lighter textured parts of the group are slightly undulating as the result of drifting. As a whole the drainage is good to excessive, and most of the group is free from alkali. In a few of the flatter areas subject to overflow the water table is high, and here slight surface concentrations of alkali may occur.

Utilization and adaptation.—A large proportion of the area of this group is cultivated, and though not so productive as some of the heavier textured alluvial soils, the soils are agriculturally important. They are used in the growing of many different crops, among which oranges, lemons, walnuts, peaches, apricots, olives, alfalfa, sugar beets, grain, grain hay, and truck crops hold commanding positions. Some of the more gravelly and stony areas and the sandy flood-swept stream channels included in the group are not tilled. These usually support a scant growth of brush and grasses of little value for grazing.

Grain, grain hay, grapes, and some of the deciduous fruits are produced under dry-farming methods, with moderate to good yields. For the crops irrigation is practiced. The soils usually require large quantities of water. On account of their light texture considerable quantities of organic matter must be continuously added if the yields are to be maintained.

For the citrus and nut crops as well as some of the deciduous fruits commercial fertilizers and manures are used more or less extensively

and in many of the orchards cover crops are grown. The greater part of the group lies within moderate distances of the markets and railroads.

HANFORD GRAVELLY AND STONY SANDY LOAMS.

The Hanford gravelly and stony sandy loams group consists of the Hanford gravelly sandy loam and stony sandy loam.

Description.—The Hanford gravelly sandy loam is a brown to grayish-brown coarse to medium textured micaceous sandy loam, carrying variable quantities of gravel. In the more level areas lying along the streams and subject to overflow the gravel is usually well rounded, and is found in patches or strips intermingled with the sandy loams and loam types of the series. On the alluvial fan areas the gravel is usually subangular and occurs in greatest abundance on the steeper slopes near the mountains. The soil is low in organic matter, and is rather loose and porous in most places. It absorbs water quickly but holds it poorly and is inclined to be droughty. The soil may continue to the depth of 6 feet or more with little change, or it may be underlain at depths below 12 inches by a lighter brown subsoil, variable in texture and consisting in places of alternating strata of partly assorted sand, silt, and gravel. The subsoil is porous and leachy. In places it is quite stony.

The Hanford stony sandy loam is a light-brown to grayish-brown, light textured, micaceous sandy loam, similar to the Hanford gravelly sandy loam except in higher content of stone. Bowlders, ranging in size from cobblestones to fragments 2 to 4 feet in diameter, in many places form 50 per cent of the soil mass and cover much of the surface. As a whole, the soil is very low in organic matter, porous, and unretentive of moisture. It normally occupies the steeper parts of alluvial fans, and occurs at the mouths of canyons or in narrow canyonlike stream courses where they enter the valley region. The surface is for the most part steeper, more uneven, and more dissected than that of the other Hanford types. As a whole, the type is less valuable for agriculture than the gravelly sandy loam. It is farmed with difficulty, and much of it is uncultivated.

Like the other recent alluvial soils, the soils of this group show considerable variation and include material that is not typical. One variation consists of small bodies of old valley-filling soils with a thin deposit of recent gravelly and stony material covering the surface. Small areas of the sandy loam and loam of the Hanford series and of the sands of the Tujunga series occur, and in some localities, particularly in the canyonlike valleys, considerable areas of Riverwash are included.

Location.—This group of soils occurs most extensively on the steep slopes south of the San Gabriel Mountains, with the largest areas in the La Canada Valley, north of Pasadena, in the vicinities of Sierra

Madre, Monrovia, and Glendora; in the region north of Pomona, Ontario, and Etiwanda, and in the vicinity of Grapeland. Smaller areas lie south of the San Bernardino Mountains, between Cajon Canyon and Plumage Creek, and a few of gently-sloping surface in the vicinities of Rialto and Bloomington. In the San Gorgonio Pass in the vicinity of Banning, and along Potrero and Mill Creeks and Potato Canyon other areas occur, and a few of minor importance in parts of the canyons of the Santa Ana River, Lytle Creek, Cajon Canyon, and of the West Fork of the Mohave River. Near Elsinore Lake and Temescal are still other small bodies of these soils.

Topography and drainage.—The soils of the group occupy steep to moderately sloping alluvial fans (Pl. V, fig. 1), rather level areas along the stream bottoms, and in a few instances recent stream terraces lying only a little above the streams. The surface is smooth and moderately even, except on some of the steeper fans and in parts of narrow canyons where it has been more or less broken and dissected by the shifting of the small streams. Generally the areas can be irrigated without much leveling, but the bowlders must be removed from the stony areas before cultivation is attempted. A few of the areas in the canyons and narrow valleys are subject to overflow, and considerable damage oftentimes results on the steeper fans during the wet seasons by the excessive run-off from the adjacent mountains. The drainage is good to excessive.

Utilization and adaptation.—Notwithstanding the fact that a large proportion of the Hanford gravelly and stony sandy loams is not tilled, this is an important group of soils in the various places where climatic conditions are favorable for the production of citrus fruits and where water is available for irrigation. Important orange districts have been developed at Ontario, Pomona, Lordsburg, Covina, Glendora, and Monrovia. The types require frequent and copious irrigation, and much labor and expense is necessary in clearing the land of stones and preparing it for cultivation. The intensively cultivated citrus crops receive comparatively heavy applications of fertilizers and manures, and considerable attention is given to the growing of cover and green manure crops to increase the supply of organic matter. Where irrigation is not developed the stony areas are little used, but grain and grain hay are grown to some extent. Deciduous tree fruits, grapes, and truck crops are also grown. Most of the areas of these soils are well located with respect to markets.

HANFORD SANDY LOAMS.

Description.—The group Hanford sandy loams includes the sandy loam and the coarse sandy loam of the series.

The Hanford sandy loam consists of light-brown or light grayish brown to brown friable micaceous sandy loam extending with little

change to a depth of 6 feet, or underlain at depths below 12 inches by a subsoil lighter brown in color and either lighter or heavier in texture than the surface soil. Near existing streams and abandoned stream channels the subsoil is likely to be made up of strata of varitextured materials. In the more level and in depressed areas the subsoil is more compact and somewhat finer in texture than elsewhere.

The Hanford coarse sandy loam, which is less extensive than the sandy loam type, is a brown to light-brown or light grayish brown gritty, coarse textured sandy loam, containing in places some subangular and rounded gravel. The soil is slightly micaceous, deficient in organic matter, incoherent and leachy. As in case of the sandy loam the material generally becomes slightly lighter in color at depths of 12 to 20 inches, and the subsoil consists of materials varying greatly in texture.

The group as mapped includes many small areas of coarse gravelly sand and fine sandy loam of the Hanford and Tujunga series. It also embraces areas of Chino soils of insufficient size and importance to warrant separation. There are zones of gradation in which the soil has some of the characteristics of the Chino, Tujunga, and other series. Near the stream courses on the steeper parts of the fans, and on the stream built ridges, the texture is lighter and the soils are more gritty and gravelly than the typical and sometimes contain a large amount of stone. In other localities where they are influenced by alluvial deposits derived from some of the red to reddish-brown old valley-filling soils or where somewhat weathered in place, the color is a pronounced brown or reddish brown. In some of the more elevated areas in the mountain region, as in the Strawberry Valley, where the rainfall is relatively heavy the soil is darker, contains more organic matter and resembles the Foster soils, some areas of true Foster doubtless being included. At the other extreme small areas near the desert region are extremely light in color and calcareous having much the same character as soils of the Cajon series.

In the Riverside and Arlington districts a notable variation of the Hanford sandy loam occurs. The surface soil is here reddish brown to red and heavier in texture than typical and at depths of 12 to 24 inches the subsoil becomes mottled and slightly redder in color; more compact, and heavier in texture than the surface material. This material apparently has been somewhat modified by weathering since its deposition and approaches in character the older valley-filling soils, particularly the Placentia sandy loam. In the San Timoteo Canyon probably 50 per cent of the area mapped as Hanford sandy loam consists of more or less weathered deposits which properly belong to the Ramona and Placentia series. These occur in small bodies intermingled with the recent alluvial deposits and could not

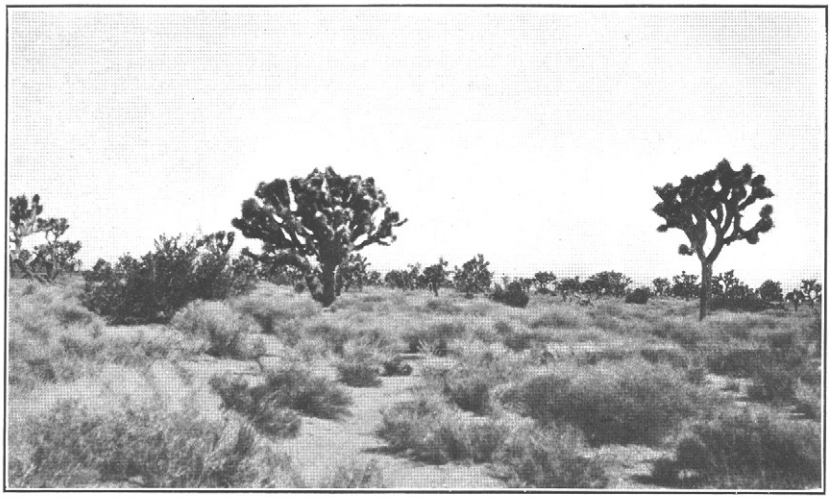
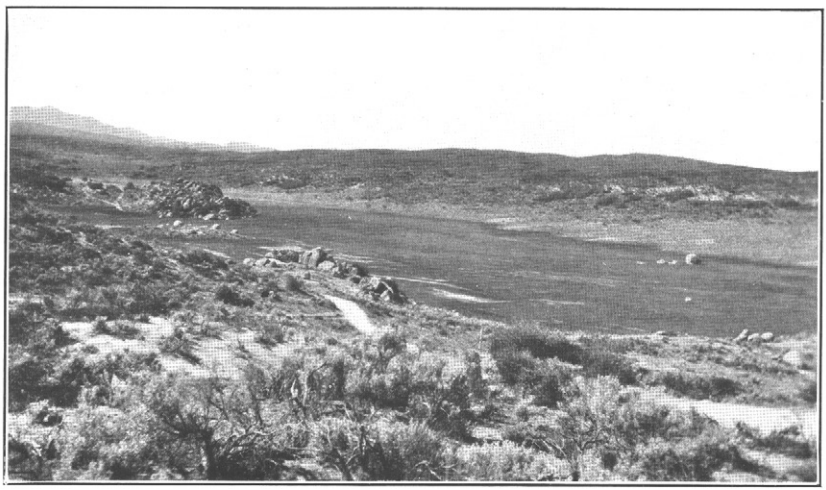


Photo from Univ. of California.

FIG. 1.—A PART OF THE MOHAVE DESERT OCCUPIED BY THE HESPERIA SANDY LOAMS.

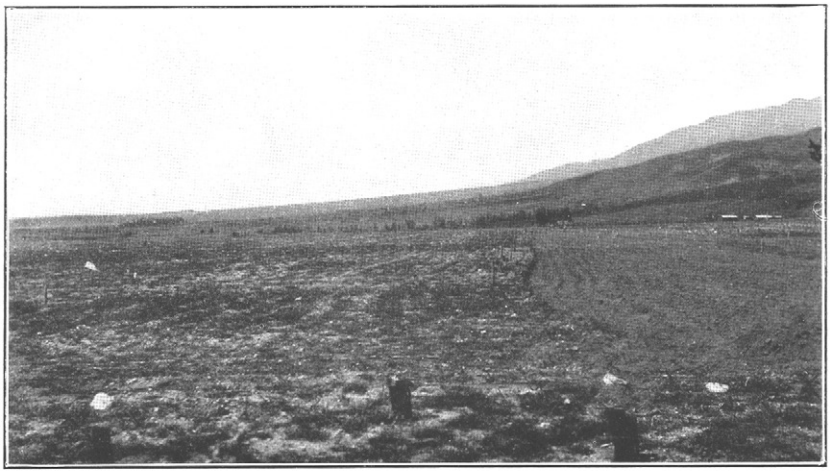
Note characteristic smooth topography and growth of desert vegetation, including open forest of the Joshua tree (*Yucca arborescens*).



S. 9330

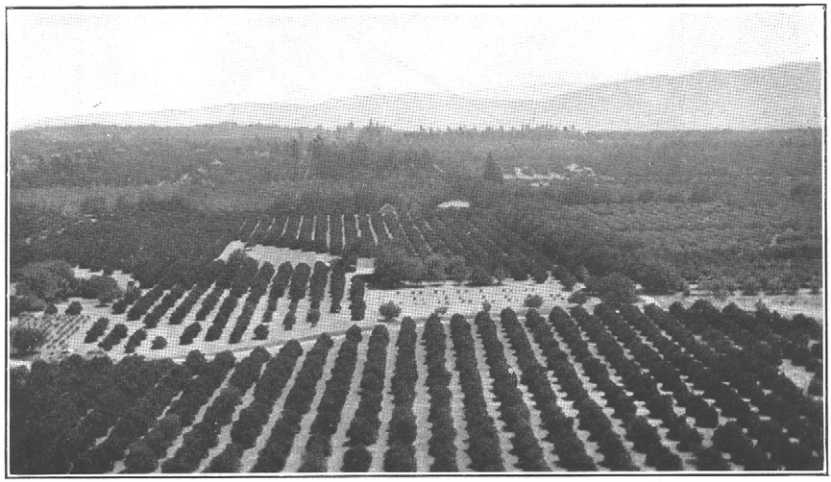
FIG. 2.—ALLUVIAL VALLEY, IN MIDDLE DISTANCE, OCCUPIED BY SOILS OF THE HANFORD AND FOSTER SERIES AND HERE UTILIZED MAINLY FOR THE PRODUCTION OF HAY.

This shows a part of the Coahuila Indian Reservation. The uplands are occupied by soils of the Holland series, with rock outcrop and local areas of rough broken and stony land.



S. 8011

FIG. 1.—AN AREA OF HANFORD GRAVELLY AND STONY SANDY LOAMS ON LYTLE CREEK FAN, WITH PROFILE OF THE STEEPLY SLOPING ALLUVIAL FAN OF DAY CREEK IN DISTANCE.



S. 7888

FIG. 2.—VIEW FROM SAN JOSE HILLS NEAR POMONA, LOOKING OVER A PART OF THE VALLEY OCCUPIED BY SOILS OF THE HANFORD SERIES, PLANTED MAINLY TO CITRUS FRUITS.

be effectively separated in a reconnoissance survey. Again in the area lying east and northeast of Winchester, there has been developed a rather heavy compact subsoil and the topography and color of the material are beginning to resemble those of the valley-filling soils. Still another variation is found in a part of the body west of Relief Hot Springs which is covered by an intermittent lake during a part of the year, and consists of stratified material variable in texture and color and modified by subjection to conditions of poor drainage.

Location.—The soils of this group cover considerable territory and are widely distributed in the survey. The larger and more important areas occur in the valley region. In the eastern part of the survey important bodies are located about San Bernardino, Redlands, Highlands, and Rialto. Small but important bodies occur in the central part of the valley region in the vicinities of Covina, Monrovia, Lamanda, San Gabriel, and north of Pasadena, and important areas in the San Fernando Valley and on the delta plains of the San Gabriel and Santa Ana Rivers in the coast region, especially around Norwalk and east and southeast of that place. Many other areas of greater or less importance are scattered in many parts of the survey.

Topography and drainage.—The soils of the group occupy gently to moderately sloping alluvial fans, stream bottoms, the floors of mountain canyons or valleys, and depressed basin areas. The areas on the alluvial fans and in the stream bottoms normally lie at elevations slightly higher than the heavier textured types of the series and lower than the Hanford sands and the Hanford gravelly and stony sandy loams. In the narrow valleys they are in many places bordered by steep slopes and areas of Rough broken and stony land. As a whole the surface is moderately smooth and favorable to irrigation. In some of the areas subject to overflow the topography is more or less undulating and broken by low ridges, depressions, and shallow washes and abandoned stream channels. Drainage is usually well developed and the soils are generally free from excessive accumulations of alkali salts. In some of the depressed areas, such as southeast of San Bernardino, near Relief Hot Springs, in some of the mountain valleys, and in several areas near the Chino soils in the coast region, the water table is near the surface and during the wet seasons water may stand upon the surface for long periods. Here the alkali content is so high as to reduce the value of the land.

Utilization and adaptation.—Where well drained the Hanford sandy loams are very important soils. On gentle slopes where climatic conditions are favorable and water is available for irrigation, as around San Fernando, Rialto, Pomona, and Highlands, important citrus fruit districts have been developed. (Pl. V, fig. 2.) On the lower flatter parts of the stream bottoms and delta plains truck

crops, grapes, alfalfa, deciduous fruits, nuts, grain, and grain hay are produced quite successfully. Except where the water table is near enough the surface to give subirrigation the deciduous fruits, alfalfa, and some of the truck crops are irrigated. Grain and grain hay, which are dry farmed, produce good yields in favorable seasons. In some areas lying at higher elevations pears and apples have been planted. Sugar beets are grown on a few of the lower lying poorly drained areas, though most of the areas with extremely poor drainage and subject to standing water during a part of the year, are used only for pasture. Grapes and olives are grown to some extent without irrigation.

Fertilizers are used for citrus crops and some of the truck crops, while cover crops are grown more or less and turned under as green manures. Crop rotation is seldom practiced. Land devoted to grain is in many cases fallowed in alternate years.

HANFORD FINE SANDY LOAM.

Description.—The Hanford fine sandy loam is one of the most extensive and important of the soil types mapped individually in this survey.

This soil typically is a brown to light grayish brown micaceous fine sandy loam, uniform in character to the depth of 6 feet or more, or becoming at 12 to 36 inches slightly lighter in color and varying in texture from sand to loam, the materials in many places being variably stratified. The subsoil may be slightly more compact than the surface soil, but is friable and permeable by water. The soil is smooth and friable, contains moderate amounts of organic matter, and absorbs and retains moisture well.

As mapped in this survey the type includes many variations that could not be separated accurately in reconnoissance mapping. In the poorly drained areas and in the zone of contact with the Chino soils the color is much darker, the texture heavier than typical, and the demarcation between the soil and the subsoil more distinct. In the Arlington and Riverside sections many of the areas have a reddish-brown color. The soil here has been modified somewhat by weathering or has been derived from the redder old valley-filling soils. Otherwise it is similar to the typical Hanford fine sandy loam. In parts of the type, especially in the areas subject to overflow, the soil is much grayer than the average and closely resembles the Tujunga soils. These light colored areas are variable in texture and structure in most cases lighter and less coherent than the typical soil and low in organic matter, and are in many places rather uneven, and modified in a few places by drifting. Considerable variations in texture exist in other localities and patches of the sandy loam and loam and other types of the Hanford series occur. Areas of Yolo and Tujunga soils of small extent are also included.

A notable variation occurs northwest of Casa Loma. Here the San Jacinto River flows in a poorly defined channel through a wide depression occupied by the Hanford fine sandy loam. The land is overflowed and a lake formed during the rainy season. The soil here is gray or dark gray and in places is very much like the materials giving the Tujunga and Chino soils. The subsoil is stratified and in places more or less mottled. These differences have developed as a result of poor drainage.

Along the coast in the vicinity of Talbert the subsoil contains well defined though discontinuous layers of peat of varying thickness.

Location.—The Hanford fine sandy loam is widely distributed with the larger and most important areas in the western part of the survey, particularly on the delta plains south and southeast of Los Angeles and about Downey, Clearwater, and Compton. Many important areas lie along the San Gabriel River from near the mountains to the coast, and areas occur in the gently sloping alluvial plain of the Santa Ana River south of Fullerton and west of Santa Ana and Orange. The type is also an important soil in the San Fernando Valley between the Santa Monica Mountains and San Fernando, as well as farther east near Pomona, Chino, and Hemet. Some areas occur north of Ontario, in the vicinity of San Bernardino, and northwest of Casa Loma. Small areas are scattered elsewhere over the survey.

Topography and drainage.—The Hanford fine sandy loam occupies the lower gentle slopes of the alluvial fans, areas in the stream bottoms, and broad, nearly level delta plains. A large part of the type in places where the streams have little fall is subject to overflow and here the surface is more or less marked by low ridges and slight depressions resulting from erosion by the water, and from deposition of sediments. Such areas in many places have a high water table and contain injurious quantities of alkali salts. In some of the lower areas and in some of the depressed valleys, such as those southeast of San Bernardino and near Casa Loma, water stands on parts of the type during the wet season, and the drainage conditions practically inhibit agriculture except where the areas have been reclaimed. In the higher lying areas the soil is more even and is free from alkali.

Utilization and adaptation.—On the better drained parts of this type and where climatic conditions are favorable, oranges, lemons, grapefruit, and walnuts are grown successfully. In most cases these crops are irrigated, though in some of the more favorable places walnuts are grown without irrigation. In areas where the water table is not too near the surface deciduous fruits, mainly apricots and peaches, give good yields. Truck crops are grown extensively, being among the principal crops in the vicinity of Los Angeles. Sugar beets are planted on the more poorly drained areas affected with alkali, which are unsuitable for other crops. Alfalfa is an

important crop, and is grown with and without irrigation. Grain and grain hay are produced under dry-farming methods and in places truck crops also are grown without irrigation. Water for irrigation is usually supplied by pumping, the cost being relatively low, owing to the existence of an underground supply at shallow depths. The more poorly drained areas of this type are not cultivated and in most places support a growth of willow, salt grasses, and other moisture loving or alkali resistant plants. Some of these low wet areas have been improved by constructing open ditches and by laying tile drains. The methods of cultivation, fertilization, and general treatment of the various crops are similar to those employed on the other soil types of the region.

The greater proportion of the areas of Hanford fine sandy loam is conveniently situated in respect to shipping points and markets and is reached by good roads.

HANFORD LOAMS.

The Hanford loam group includes the loam and silt loam types of the Hanford series.

Description.—The Hanford loam is a brown to light-brown, micaceous, medium textured loam, in places 6 feet deep, but in most instances underlain at 12 to 18 inches, by a somewhat lighter colored subsoil varying in texture from a sandy loam to silt loam or clay loam. In many places the subsoil consists of interbedded layers of heavy and lighter textured material and here and there it is more or less gravelly. The soil is more compact than the lighter textured types of the Hanford series, is usually not so gritty, and is retentive of moisture. It contains moderate quantities of organic matter and is for the most part friable and easily tilled.

The Hanford silt loam covers but a small area. It is a fine, smooth textured soil, as a whole more compact and retentive of moisture than the loam. In the depressions and flatter areas the color of the soil is usually a darker brown, approaching that of the Chino series. The silt loam is less subject to overflow than most of the loam and lighter textured types and it generally has a surface less broken by the courses and abandoned channels of streams.

The Hanford loams are subject to considerable variation and include areas of material differing widely from the typical. In some of the depressed areas a larger content of organic matter produces a darker color, the texture is heavy, and in a few places the soil appears to have been puddled. In other places, especially those subject to overflow, strips of gravelly and sandy material and small areas of Tujunga soil are included. Near San Fernando the subsoil is heavier and more compact and has a slightly reddish color, resembling that of the old valley-filling soils. Near Riverside and Arlington a reddish-

brown variation occurs, in which the type is similar to the Placentia loam.

Location.—The Hanford loams group, which is not so extensive as the Hanford sandy loams, occurs in small areas in various parts of the valley region. Important areas are mapped in the San Fernando Valley in the vicinity of San Fernando, and near Van Nuys and Glendale. One of the larger areas of loam texture lies west of Los Angeles and smaller areas are situated on the gently sloping alluvial fans south of the Santa Monica Mountains near Hollywood and to the west. In the coast region on the delta plains many areas occur, mainly in the vicinity of Westminster, west of Los Alamitos, south of Norwalk, and southwest of Anaheim. Other small areas are developed in the Eagle Rock Valley and in the region between Savannah and the San Gabriel Mountains. Other areas occur north of Puente, near Pomona, north of Glendora, north and southeast of San Bernardino, in the vicinities of Riverside and Arlington, and north of Hemet. A poorly drained area containing alkali lies northeast of Lakeview.

Topography and drainage.—The soils of this group occupy level stream bottoms, parts of broad delta plains, the lower slopes of alluvial fans, and a few depressed basins. Except in a few places where it is more or less furrowed by stream channels the surface is smooth and even and easily prepared for irrigation. In some of the flatter areas a high water table exists, and near the coast and in some of the depressed valleys they are poorly drained and affected with alkali. As a whole, however, the soils are well drained and suitable for crop production.

Utilization and adaptation.—The Hanford loams form important farming areas and are cultivated over most of their extent. Where climatic conditions are favorable and water is available for irrigation, oranges, lemons, and walnuts are produced successfully. Well-drained areas, not so free from frosts, are largely used for peaches, apricots, olives, grapes, truck crops, and alfalfa. In the more poorly drained areas affected by alkali, grain, grain hay, some truck crops, and alfalfa are grown. With the exception of grain, grain hay, grapes, and olives, practically all of the crops are grown with irrigation, the water being supplied generally by pumping from underground sources. The yields of irrigated crops are good, and dry-farmed crops apparently give better returns than on lighter textured types.

Fertilizers are used to about the same extent as on the other Hanford soils.

HANFORD CLAY LOAMS.

Description.—In the Hanford clay loams group are included the clay loam and silty clay loam of the series.

The Hanford clay loam is a brown to slightly reddish brown medium textured clay loam. It contains moderate amounts of organic matter, and is moderately compact and retentive of moisture. As in the other types of the series the soil material may extend without change to depths of 6 feet or more. Where this is not the case subsoil of lighter color develops between 12 and 20 inches which as in the other Hanford soils varies in texture and is more or less stratified. For the most part this subsoil is permeable and favorable to root development.

The Hanford silty clay loam is a smooth-textured brown silty clay loam, with variations ranging from slightly reddish brown to grayish brown or dark brown, containing moderate quantities of organic matter. The subsoil is in many places similar to the surface soil in texture and structure but as in case of the clay loam and other types of the series may be lighter or heavier or consist of stratified deposits of varying textures.

A number of variations occur in these soil types. Parts of the area near Hollywood which lies on the lower part of an alluvial fan, differ slightly from the typical in having a thin covering of grayish deposits along the small stream ways draining some of the lighter textured soils. In other places in this same area the lower subsoil is heavy and compact and sometimes calcareous, like that of the old valley-filling soils. The area east of Nigger Slough is poorly drained and subject to overflow, contains more organic matter and is dark in color, approaching in character the soils of the Chino series. The areas near Arlington are redder in color than the average of the type. Areas occurring in depressions, for the most part poorly drained, have a more or less puddled soil.

Location.—The clay loam type is confined to two areas in the western part of the survey, one lying southwest of Hollywood and the other east of Nigger Slough. The most important area of the silty clay loam texture is about 2 miles west of Arlington in the central part of the survey.

Topography and drainage.—These soils occupy areas which normally lie at lower elevations than the lighter textured alluvial soils. The surface is generally smooth and easily prepared for irrigation. Those areas lying on the alluvial fan ordinarily have sufficient slope for good drainage but the drainage of some of the depressed areas is poor, as they are not only overflowed at times, but water frequently stands on the surface during the wet season. Considerable quantities of alkali have accumulated in such areas.

Utilization and adaptation.—The Hanford clay loams are largely utilized for the growing of sugar beets. Some truck crops, grain, and grain hay are produced without irrigation, and alfalfa, where irrigated, produces good yields on the well-drained areas. Areas with very poor drainage are used only for pasture.

Cajon Series.

The soils of the Cajon series are confined to the desert region. They are grayish brown to brown in color and consist of recent alluvial deposits, derived from crystalline quartz bearing rocks, with those from the granitic formations predominating. They are thus similar to the Hanford soils in formation, origin and color, but their calcareous nature, both soil and subsoil effervescing, places them in a distinct series. The soil in many places extends to a depth of 6 feet or more with little or no change in the texture or color. In other places the subsoil is stratified, the texture of the different layers varying greatly, and has a tendency to be slightly lighter in color. The Cajon soils occupy rather steep to gently sloping alluvial fans, gradually merging into the smooth plains of the desert, or narrow flood plains and low terraces along the main streams. The surface is smooth to slightly undulating, the latter condition resulting from the action of the wind and small intermittent streams. The soils are well drained. Only the Cajon sandy loams group is developed in this area.

CAJON SANDY LOAMS.

In the Cajon sandy loams group have been placed a number of the types of the Mohave Desert. Of these the Cajon sandy loam is the most extensive, and there are small areas of coarse sandy loam, fine sandy loam, and stony sandy loam of the series. These soils are the desert prototypes of the Hanford series, to which they conform in color, origin, and mode of formation, but it was considered advisable to place them in a separate series, owing to the fact that, occurring under desert conditions, they have suffered less leaching and both the soil and subsoil material are calcareous, effervescing freely when brought in contact with acid. The absence or presence of lime is the essential distinction between the Hanford and the Cajon series.

Description.—The Cajon sandy loam is a brown to light-brown or light grayish brown medium to light textured sandy loam, low in organic matter, calcareous, micaceous, and of open structure. The soil absorbs water rapidly, but loses it as rapidly. The soil may extend to depths of 6 feet or more with little change, but like the other recent alluvial deposits, the subsoil lacks uniformity, and may range from a sand to a sandy loam or loam. In places it is stratified and contains gravel. It, like the soil, is normally high in lime.

The Cajon coarse sandy loam is similar in color and general character of soil and subsoil to the Cajon sandy loam, though its coarser texture makes it more gritty and slightly less compact than the latter. It contains little organic matter, and is slightly less retentive of moisture than the sandy loam.

The Cajon fine sandy loam is a brown micaceous fine sandy loam of smooth feel, somewhat less porous and leachy, and more retentive of moisture than the sandy loam. The subsoil is in most places similar to the surface soil, but may be slightly lighter in color and may consist of alternating strata of rather coarser or of finer sediments.

The Cajon stony sandy loam is a rather coarse to medium textured sandy loam of light-brown to brown color carrying much gravel and stone on the surface and embedded in the soil mass. This type normally occupies the steeper parts of the alluvial fan areas and areas along the stream courses. In places large bowlders, which would seriously interfere with cultivation, are numerous.

The soils of this group are subject to more or less variation in texture, and may include locally small areas of the sand and the loam of the series.

Location.—This group of soils is confined to the northern part of the survey, where it occupies large, uniform areas in the Mohave Desert. Areas of smaller extent lie about Valyermo and along Pallett Creek, and in the broad upper reaches of Cajon Canyon. There is some development of the group farther east along the Mohave River, and in the recent alluvial valleys of Horsethief Canyon and in its tributary Antelope Valley. The small areas in the vicinity of Pallett and Valyermo, and east of the Burcham Ranch on the West Fork of the Mohave River are of fine sandy loam texture, representing the principal development of this type. The principal areas of the stony sandy loam type lie along the main channels of Rock Creek from Shoemaker to the boundary of the survey and in the part of the desert occupied by the alluvial fan of Sheep Creek.

Topography and drainage.—The topography is very much like that of the Hanford sandy loam. The soils occupy the alluvial fans formed by the streams debouching from the San Gabriel Mountains or have been formed from alluvial deposits laid down by streams in small valleys in the mountain region. The surface is generally smooth and even, with a few irregularities in the stony areas and in the areas subject to overflow. In the areas of lighter textured soils it is slightly uneven as a result of wind action. The drainage of both soil and subsoil is excessive, and in most places a large application of water would be necessary in irrigation.

Utilization and adaptation.—Practically all of the soils of this group remain in their virgin state owing to unfavorable climatic conditions. In some of the most favorably situated areas, which lie at higher elevations, where the precipitation is heavier, dry-farmed grain hay and grain sorghums are grown and a few apple and pear orchards have been planted. In a few places where a little water for irrigation is drawn from Pallett and Rock Creeks, some alfalfa and deciduous

fruits are successfully produced, but the acreage is small. The uncultivated areas are occupied by a sparse cover of desert vegetation. This affords grazing of low value.

Foster Series.

The soils of the Foster series are typically dark brown to dark grayish brown, with variations of dark-gray color. The material may extend to depths of 6 feet or more with little or no change in color or texture, or a subsoil lighter in color and consisting of alternating strata of lighter and heavier textured material may intervene. The soils consist of recent alluvial deposits which have been derived mainly from granitic rocks. They occupy gently sloping alluvial fans, level flood plains, and low recent terraces. In many places the drainage is poor, but in the typical areas it is moderately good. Accumulations of alkali exist in the low wet areas. Concentrations of lime do not occur.

The series is closely related to the Hanford series, from which it is distinguished by a darker color and less well developed drainage. One group, the Foster sandy loams and loams, is mapped.

Foster sandy loams and loams.

The Foster sandy loams and loams group consists mainly of the sandy loam, fine sandy loam, and loam types of the series. Associated with the loam bodies are patches of silty clay loam, which are small in extent and of little importance.

Description.—The Foster sandy loam is a dark-brown to dark grayish brown, in places dark-gray, rather coarse to medium textured sandy loam. The soil is usually distinctly micaceous, contains moderate amounts of organic matter, is generally friable and easily tilled, and is fairly retentive of moisture. The soil material in places is uniform to the depth of 6 feet or more, no subsoil occurring. In other places at a depth of 10 to 20 inches the material is lighter in color, and may consist of layers of either lighter or heavier texture than the surface soil.

The Foster fine sandy loam is a brown to dark-brown or dark grayish brown fine sandy loam, usually highly micaceous and of smooth friable structure. It is similar in essential features to the Foster sandy loam, but contains somewhat more organic matter and is slightly more retentive of moisture.

The soils of the Foster loam and the Foster silty clay loam resemble the Foster sandy loam and fine sandy loam, except in texture, in a slightly darker color, and a higher organic matter content. They are compact and frequently bake hard and clod when dry.

The group as a whole lacks uniformity. A variation occurs south of Lindarosa near the southern boundary of the survey and southeast of Elsinore Lake, where they resemble in some respects the old valley-

filling soils. The topography is slightly undulating, and in places the subsoil is more compact than the surface soil and frequently mottled. In a few of the small valleys the subsoil is gravelly and in some of the depressed basins, residual material or bedrock lies near the surface.

Location.—The group of Foster sandy loams and loams is confined to small areas in the eastern part of the survey. One of the more important areas agriculturally, consisting largely of the sandy loam and fine sandy loam, borders the northwestern part of Elsinore Lake. Other small areas occur in Hemet Valley above the Hemet Reservoir, along the southern boundary of the survey south of Lindarosa, and near Murrieta and Wildomar. Others are developed in depressions along some of the drainage ways in the Coahuila and Terwilliger Valleys in the southeastern part of the survey, and in Holcomb and Bear Valleys and near Baldwin Lake in the San Bernardino Mountains. Small areas occur elsewhere in the survey.

Topography and drainage.—The Foster sandy loams and loams occupy the lower parts of gently sloping fans, and the flood plains of streams with low gradients, and small basins in the mountains. The surface is smooth and even except in the narrow valleys, where it is broken in places by the channels of streams.

Utilization and adaptation.—The greater part of the group is uncultivated and is used mainly for pasture. Some of the small wet areas along the streams and in depressions, considering their size, furnish considerable grazing. Grain and grain hay are grown moderately well without irrigation on the better drained parts of the group, and a small quantity of alfalfa is produced where irrigation has been supplied or where the land is naturally subirrigated. The area near Elsinore, which is quite important agriculturally, is utilized largely for growing deciduous fruits. Walnuts are grown here to a small extent.

Chino Series.

In the Chino series are included types with dark-gray or dark brownish gray to black soils, 6 feet or more in depth, or where developed, underlain by a lighter gray to brown mottled subsoil. The subsoil contains much lime, which has accumulated as the result of restricted drainage, the drainage as a whole, being poorly developed. Accumulations of alkali also are common in many places. Soils of this series occupy low flat parts of alluvial fans, and alluvial valley basins of flat to gently sloping, smooth topography. The series is distinguished from the Foster and the Hanford series on the basis of darker color and calcareous subsoil and they differ from the Yolo series in origin and color. The soils are mapped in two groups. The Chino loams and the Chino clay loams and clays were recognized under this series.

CHINO LOAMS.

Description.—The Chino loams group includes the Chino loam and the Chino silt loam.

The Chino loam is typically a dark-gray to black loam, generally of rather silty loam texture, from 24 to 35 inches deep containing finely divided mica and much organic matter. It is generally moderately friable, but is sticky when wet, and where heavier than typical may puddle if cultivated under unfavorable moisture conditions. The subsoil may be either lighter or heavier in texture than the surface soil and may consist of interstratified layers of sediments ranging from a fine sand to a heavy loam or silt loam. The color is gray to brownish gray of lighter tints than those of the surface soil. The material is calcareous, the lime occurring as small nodules, seams, or, where most concentrated, as marly beds. The material is in places rather compact, but is generally of a structure favorable to the movement of moisture and development of roots. The type is retentive of moisture and is easily maintained in good physical condition, if ordinary care is taken in cultivation.

The Chino silt loam is a dark-gray to black friable micaceous silt loam, generally smooth in texture. The quantity of organic matter is in most areas fairly large and the soil is friable and is readily maintained in a good condition of tilth under favorable conditions of drainage and cultivation. It is retentive of moisture and readily permeable to roots. In areas a brownish soil occurs. This variation is developed in the Los Angeles region, and here the material closely resembling the Hanford soils is included. In certain alkali areas the soil is a pale gray and very compact.

The subsoil may be similar to the surface material, but generally consists of a dark grayish brown or brown to gray stratified material, the layers varying from fine sand to silt and clay. The lighter textured layers are usually brown and the heavier or finer parts grayer or darker colored. Concretions or small nodules of lime appear in these strata. Mottling of gray and red, yellow, or brown appears in the subsoil material where the drainage is poorer.

This group includes a local area of somewhat lighter texture, consisting of fine sandy loam or silty fine sandy loam. Some of these areas owe their departure from the typical to a shallow overwash of stream deposits.

While the subsoil of this group is typically and consistently calcareous, a wide range in lime content occurs and individual samples may in some cases show but feeble or no effervescence with acid. On the other hand an extreme development of the calcareous subsoil may occur, particularly in the lower lying basins or flats, in which the material is a marl, light gray or white when dry, and tending to form a hardpan, except where continuously moist.

Location.—This group of soils is extensive and important. It generally occurs in association with the heavier or lower lying types of the Hanford series, and as mapped may include some true Hanford material. The larger and more important silt loam areas occur in the region between Los Angeles and San Pedro Bay. Other less extensive areas lie south of Culver City, southwest of Whittier, and in the vicinity of Downey. Others of moderate extent occur in the Santa Ana district in the vicinities of Fairview and Los Alamitos. This type is also represented by several tracts in the interior valleys north of Rincon and around San Bernardino. The areas of Chino loam are less extensive and occur mainly in the vicinities of Pomona and Chino. The lighter textured variations included with the soil group are most pronounced in tracts about 6 miles north of Rincon and about 1 mile east of San Bernardino, and in the western part of the survey near Clearwater and Watts.

Topography and drainage.—The soils of this group occupy the lower and flatter margins of recent alluvial fans, and shallow depressions of restricted drainage. The surface is smooth and uniform, except for a few minor irregularities, and the land is easily prepared for irrigation. Some of the tracts occupy swampy or permanently wet depressions, where a high water table, usually within 6 feet of the surface, generally exists. During wet periods the soils are sometimes flooded by drainage from higher lying adjacent types, and alkali salts have accumulated in excessive quantities in much of the land. Some of the areas, particularly in those lying south from Los Angeles, have been improved by artificial drainage, which has lowered the water table and kept under control to some extent the alkali salts by leaching and by removal of the dissolved salts in the drainage waters. Some of the soil tracts are traversed by winding drainage channels, but the natural drainage is on the whole poorly established. The brown variations lie somewhat higher than the rest of the group and are better drained.

Utilization.—The soils of this group are restricted in their usefulness by the generally unfavorable drainage conditions, but nevertheless they constitute important agricultural lands. The best situated areas or those which have been reclaimed or improved by drainage are used in the production of alfalfa, potatoes, corn, berries, and truck crops. Grain is also grown to some extent and walnuts have been planted on a few of the most favorably situated and better drained sections. The poorly drained areas and those which have accumulations of alkali salts are generally devoted to sugar beet culture, which flourishes and has formed an important industry. Small parts of the areas of high alkali concentration and tracts that in their present condition are too wet for cultivated crops are utilized as pasture land.

Fertilizers are not much used, though stable manure is applied to a limited extent. Irrigation is practiced in parts of the areas. Most of them lie adjacent to good highways and, when improved by drainage, and where necessary by facilities for irrigation, are extremely productive. Such tracts have a value of several hundred dollars an acre. Some of the more highly valued areas devoted to intensive crops bring an annual cash rental of $20 to $45 an acre. Water for irrigation purposes in most places may be obtained cheaply by pumping.

Chino loam, mucky phase.—The material mapped as the Chino loam, mucky phase, is not very extensive. It is composed largely of organic matter, and when dry it is so light in weight that it will float on water. The surface soil is for the most part a black Muck, containing a variable but small admixture of silt and other fine textured mineral material. It is quite friable and has a high water-holding capacity. At a depth of 15 to 18 inches the proportion of mineral matter in the soil increases and occurs in strata, alternating with pockets or layers of less well decomposed organic matter or Peat. The subsoil is more porous than the soil and contains large quantities of undecayed plant roots which make the mass fibrous and spongy. In places calcareous deposits appear in the subsoil material, but as a whole the areas are practically free from alkali salts. The depth of the surface and subsoil material is generally more than 6 feet.

The greater part of the Chino loam, mucky phase, occupies depressed areas in swampy flats kept more or less wet by springs and seepage water. Other parts are situated below the bluffs occupied by old Coastal Plain deposits, and receive seepage waters from these higher elevations. Where the soil merges with other soils the depth of the mucky material is shallower than the average and contains more mineral material. In a few places a thin deposit of recent alluvial material has been laid down over the surface.

Location.—The Chino loam, mucky phase, is confined to several small areas in the southwestern part of the survey. One body lies near Alimitos Bay and several others occur between Westminster and the ocean. A small tract is found near Talbert and another northeast of Thurin.

Topography and drainage.—The surface is moderately smooth, but slight ridges and hummocks are common. Overflow seldom occurs but the whole type has a high water table and poor drainage. This condition has been greatly improved in places by the installation of tile drains, which have lowered the water table so that cultivation is possible.

Utilization and adaptation.—On account of the small extent this type is of little agricultural importance. The greater part is in cultivation, being utilized mainly for the production of sugar beets and

truck crops. In many places cultivation is difficult owing to the spongy nature and unstable condition of the soil mass, which will not support the weight of work stock and farming implements. On account of the high water table irrigation is not as a rule necessary. The yields of all crops are generally large.

CHINO CLAY LOAMS AND CLAYS.

Description.—The Chino clay loams and clays group includes the clay loam, silty clay loam, silty clay, and clay types of the series.

The Chino clay loam consists of a dark-gray or black clay loam usually high in organic matter and of rather smooth silty texture. It is typically distinctly micaceous and under favorable conditions of moisture friable, puddles to some extent when wet, and has a tendency to bake upon subsequent exposure if not properly tilled. Brownish variations occur in zones of gradation into adjacent soils of the Hanford series. Material similar to the surface soil may extend to 6 feet or more, but as a rule the lower part of the soil profile consists of brown or grayish-brown to gray layers of material varying from fine sand to silt and clay in texture. The lighter textured strata are usually of pronounced brownish color and are friable and porous. The layers of heavier texture are of darker color, and more compact, and generally contain small lime concretions or nodules. In extreme areas light-colored beds of marly material are developed. In poorly drained areas the subsoil is mottled with gray, brown, and yellow. Small areas are included in which the organic matter content becomes abnormally high, the material being more or less peaty, and some small bodies consist of true Muck or Peat. Pockets or layers of similar character are encountered here and there in the subsoil in the lower lying and more poorly drained places. In the vicinity of areas of tidal marsh the surface material sometimes consists of alluvial deposits and the lower material of compact gray or drab mottled silty clay or clay tidal marsh material, ordinarily high in marine salts. A local variation in this type consists of areas of fine sandy texture, more porous, often very micaceous, and, as a rule, with shallow soil. In a few localities of this character adjacent to the ocean or to areas of tidal marsh the material contains small marine shells.

The Chino silty clay loam is similar in essential features except texture to the Chino clay loam. The subsoil is usually gray or brownish gray, generally as heavy as or heavier in texture than the surface soil, and containing calcareous nodules, seams, or marly beds. Like the clay loam it includes brownish or light-grayish variations and small streaks or bodies of lighter and more sandy texture, but the conditions are generally somewhat more uniform than in the clay loam type. In some places the subsoil material is but slightly calcareous. The soil is sticky when wet but is friable and granulates when worked under favorable conditions.

The Chino silty clay is in most places distinctly darker in color than the preceding types. It is more compact and less frequently micaceous than the lighter-textured soils. The organic matter content is high, and under favorable conditions of moisture it can be maintained in a granular, friable condition, though if stirred when wet it is readily puddled, and some difficulty is experienced in its cultivation. The subsoil is similar in general features to those of the preceding types, being frequently mottled and always calcareous, but analysis would probably show most of it to be a silty clay loam or silty clay in texture.

The Chino clay, which is of little importance, includes some areas of soil similar to the Chino silty clay, though of lower silt and higher clay content. The clay is generally black in color, and rests upon a rather heavy compact dark-colored calcareous subsoil. It is in general somewhat less friable than the silty clay type. The organic content is high, and the surface frequently cracks and checks during dry periods, approaching in structure a clay adobe.

Location.—This group of soils occupies extensive and important areas west and southwest of Los Angeles, in the Santa Ana River delta region in the vicinities of Santa Ana, Los Alamitos, and Newport; in the region about El Monte and Puente in the San Gabriel Valley and in the country around Chino, Pomona, and Rincon in the central part of the survey. Small areas occur near San Bernardino, and an area of silty clay and clay occupies the lower delta or depression trough of the San Jacinto River in the south-central part of the survey from near Lakeview to beyond Ethanac. This latter body is hardly typical of the Chino soils and may be recognized as a distinct soil series in future soil survey work of greater detail. The clay loam type is well developed west and southwest of Los Angeles, a quite extensive tract of irregular outline occupying the general depression extending from Sherman southeastward to Hyde Park. Other relatively small bodies of this type occur in the vicinities of Bolsa, Westminster, and Alamitos Bay in the Santa Ana region.

The principal areas of the Chino silty clay loam lie south of Los Alamitos, and make up the most of the soils of this group mapped around Chino, Rincon, and El Monte. The silty clay type occurs mainly near Huntington Beach and Alamitos Bay, and between Santa Ana and Newport.

Topography and drainage.—The soils of this group occupy the lower flatter margins of alluvial fans and stream deltas. The surface is generally flat or has but very gentle slope. Parts of the areas consist of shallow, basinlike depressions of sluggish drainage, and supporting a swamp vegetation. A high water table, lying only a few feet below the surface, is characteristic of this group, and parts are wet and marshy and contain accumulations of alkali. Some of the soil areas

occupy broad shallow troughs or depressions through which drainage from others lying higher takes place, and lower lying tracts are sometimes subject to overflow by local streams or by the run-off. Marked improvement in drainage and alkali conditions have been effected by artificial drainage. The surface is usually smooth and easily prepared for irrigation. Parts of extensive artesian basins are included, and waste water from flowing wells and springs tends to raise the already normally high water table and otherwise to intensify the conditions of poor drainage

Utilization.—While lower lying tracts are utilized only for grazing, on account of unfavorable drainage and alkali conditions, the greater part of these soil areas is devoted to crops, usually under intensive cultivation. Sugar beets and truck crops are widely produced, the latter, grown mainly in the region west and southwest of Los Angeles, consist of sweet corn, potatoes, lima beans, tomatoes, berries, etc. Celery is an important product south of El Monte. In the Chino region the soils are devoted mainly to sugar beets. Alfalfa and grain and grain hay are grown on various parts of the group, where better drainage prevails. The best results are obtained where favorable moisture conditions are maintained by drainage and irrigation. Water for irrigation, which is practiced to some extent, is obtained at moderate expense by pumping from an underground source and in some localities from flowing wells.

Little or no commercial fertilizers are used, but barnyard manure is applied to a limited extent. Under favorable conditions of moisture, drainage, and cultivation, yields are moderate to large and the lands are highly valued. In some localities where the farms are devoted to crops intensively cultivated a cash rental of $20 to $40 an acre is paid, and the lands are valued at several hundred dollars an acre, but the soils of the group vary widely in productivity and value with position, drainage, and development. The water table is generally too near the surface for tree fruits and the types are best adapted to the more shallow rooted crops, and where alkali salts occur to sugar beets or other more resistant crops. The silty clay and clay types have been least developed, generally have the lowest value, and are of least agricultural importance.

Most of the areas of this group are reached by improved highways and are favorably situated with respect to railways and shipping points.

Yolo Series.

The soils of the Yolo series are recent alluvial types composed of materials derived principally from sedimentary rocks, but to some extent from valley-filling and coastal plain deposits. The surface soils are typically brown, with grayish-brown or light-brown to dark-brown variations, and the subsoil yellowish brown or light brown to

grayish brown. The subsoil may be similar to the surface soil in texture, may consist of either heavier or lighter material, or may be composed of alternating strata of light and heavy textures. The soils of this series occupy alluvial fans and alluvial valley slopes, stream bottoms, and low recent terraces. The surface is usually smooth except in a few places where it is interrupted by the stream courses and small erosions. The Yolo soils are for the most part well drained. They differ from the Hanford soils in origin, and from the Dublin series of similar origin in having a lighter color. Three groups of Yolo types are shown in the accompanying map.

YOLO SANDY LOAMS.

Description.—The group Yolo sandy loams includes the sandy loam, the gravelly sandy loam, and the fine sandy loam of the series.

The Yolo sandy loam consists of a brown or grayish-brown medium textured sandy loam, which may extend to depths of 6 feet or more with practically no change, or at a depth of 10 to 16 inches, develops a lighter colored subsoil either heavier or lighter than the surface soil, or consists of interstratified layers of silt, sand, and gravel. The type contains moderate amounts of organic matter and is usually nonmicaceous and rather gritty. It has an open friable structure, is easily tilled, and absorbs water rapidly. In most places, excepting in the coarsest textured parts near some of the streams, it is moderately retentive of moisture, but crops if not irrigated frequently suffer from drought.

The Yolo gravelly sandy loam is a brown to grayish-brown sandy loam containing varying quantities of gravel, of small to medium size, rounded to subangular in shape, and derived mainly from sedimentary rocks with a few local areas in which it is of metamorphic or igneous character. The gravel generally occurs in quantities sufficient to modify structure and to affect the tillage and the power of the soil to hold moisture. The surface soil may extend to depths of 6 feet or more with little variation, or the subsoil may grade into strata relatively free from gravel or much more gravelly than the surface. The subsoil generally consists of a loose porous gravelly sand or gravelly sandy loam of low moisture holding capacity, but in a few places, mainly away from the streams, the subsoil is heavier in texture than the surface soil, a heavy sandy loam, or loam. The soil contains low to moderate amounts of organic matter. The subsoil generally favors the development of deep root systems.

The Yolo fine sandy loam consists of a brown or light-brown fine sandy loam, moderately low in organic matter, and of porous structure. The subsoil, like that of the other Yolo soils, is subject to much variation and in the flatter areas away from the streams in

many cases heavier in texture and slightly more compact than the surface soil. In most instances it is lighter in color. Along some of the main streams more or less gravel occurs in the fine sandy loam areas, but in few areas is it abundant enough to greatly modify the structure or the productiveness of the type.

The group as mapped includes many small areas of the heavier textured Yolo soils and of old valley-filling material which has been covered by superficial deposits of sandy loams of more recent origin. In other places the soil material is comparatively old and has more or less weathered and aged, until it resembles the material giving the old valley-filling soils. Also near the mouths of some of the canyons, in places along the major streams, and near the hills patches carrying stones and bowlders on the surface occur. Where the soils of the Yolo and Hanford series are closely associated small bodies of the latter are mapped with the Yolo groups.

Location.—The most extensive and important areas of the group are situated in the San Fernando Valley along and near the western boundary of the survey. A number of small gravelly sandy loam tracts lie near the mountains in the vicinity of Corona and from Rincon southeast to Temescal Wash. A few small scattered areas occur around the San Pedro Hills, north of Gardena, and southeast of Palms; while narrow strips occupy the San Juan Canyon and other canyons in the Santa Ana Mountains.

Topography and drainage.—The group occupies alluvial valley slopes, alluvial fans, and stream bottoms. Some of the flatter areas and narrow deposits along streams are marked by shallow meandering stream ways and in places the alluvial fans have been more or less eroded or dissected by the courses of streams. Some of the lighter textured areas have had their surfaces modified to a slight extent by wind action. Aside from these mentioned irregularities, the surface of the group is moderately smooth and even, and favorable to irrigation. In nearly all the areas the drainage of both soil and subsoil is good. In a few small areas occupying depressions having comparatively heavy subsoils, poor drainage and alkali exist. The gravelly areas are found on the steeper slopes of the alluvial fans and along the streams which overflow, and the sandy loam and fine sandy loam areas occupy the slopes and stream bottoms of gentle gradient, or lie in low positions.

Utilization and adaptation.—The soils of this group, while not extensive, are locally important in the agriculture of the region. Dry-farmed areas are utilized mainly for grain and grain hay, which yield moderately well in normal years. Where irrigation has been developed, apricots, peaches, citrus fruits, alfalfa, beans, truck crops, and sugar beets are grown extensively. The acreage devoted to grain is being encroached upon by the more profitable irrigated crops.

The most favorably situated areas are utilized for citrus and walnut groves. A small part of the type, consisting mainly of some of the most gravelly areas where irrigation is not possible, is not tilled and is used for pasture. The handling of the soil and general fertilizer practice is the same as on the other recent alluvial soils, except that probably the sandy loams require more organic matter and larger applications of fertilizer than the heavier types in order to maintain the normal yields. As a whole, the yields are slightly lower on these soils than on the Yolo loams. The soils are well situated with respect to markets and are well supplied with roads.

YOLO LOAMS.

Description.—The Yolo loams group includes the Yolo loam, the Yolo gravelly loam, and the Yolo silt loam.

The Yolo loam is typically a brown to a slightly grayish brown medium textured, nonmicaceous loam, containing moderate quantities of organic matter, fairly compact, but friable under cultivation. The subsoil is in many places lighter in color than the surface soil, may be identical with it in texture to a depth of 6 feet or more, but in places it consists of stratified material ranging in texture from sandy loam to clay. The subsoil is in places calcareous. It is retentive of moisture and favorable to the growth of deep rooted plants.

The Yolo gravelly loam is similar to the Yolo loam. It contains enough medium to small gravel to make it a gravelly type. This gravel is subangular to rounded in shape and composed of sedimentary rocks. In places the gravel content is excessive greatly modifying the structure of the type and seriously interfering with tillage; in other places it occurs in only small amounts. Below 15 inches the subsoil generally is slightly heavier in texture, and a light brown to reddish brown in color. Like the surface soil it normally contains much gravel.

The silt loam type, which has a very small extent, resembles the loam except in texture. It is a little more compact and more retentive of moisture than the loam, and a somewhat better soil.

The group includes a number of variations in texture, color, and other features. In places where the soil is comparatively heavy and the content of organic matter high, the color is almost black. Such areas ordinarily grade into soils of the Dublin series. In the region about Santa Ana and Tustin the group includes some small areas of micaceous material closely resembling that giving Hanford soils.

In places the soil and subsoil material is less than 6 feet deep and such areas for the most part are confined to situations near the residual soils or occur in the narrow valleys at some of the minor streams.

Location.—This group of soils is most extensive in the western and southern parts of the survey. Comparatively small areas occur in

the San Fernando Valley north of the Santa Monica Mountains, also in the valley east of Pacoima, and west and northwest of the San Fernando Mission. Important areas are situated south of the Santa Monica Mountains near Hollywood and east of Santa Monica, south of Inglewood, and around Gardena and Nigger Slough. A few small tracts lie north and east of the San Pedro Hills. Other areas of this group are developed north and southeast of Whittier and in narrow belts along some of the valley slopes and streams in and near the Puente Hills, the largest and most important area lying southwest of Puente. Other important areas lie in the neighborhood of Santa Ana, Fullerton, and Corona, and along some of the streams in the San Joaquin Hills.

Topography and drainage.—The areas of this group occupy the level flood plains, steep to gently sloping alluvial fans, and the narrow valleys bordered by steep broken slopes. In a few places the surface is dissected and in others rather undulating, consisting of depressions and minor stream-built ridges, but as a whole the areas are moderately smooth and even and are well suited for irrigation. The drainage is good, and there has been little accumulation of alkali except in some of the small depressed tracts, where the water table is high. Here alkali in injurious quantities is not uncommon.

Utilization and adaptation.—The soils of this group are productive and agriculturally important. The greater part of the area is under cultivation. Unirrigated land is used mainly in the production of grain, grain hay, and beans. The yields of these dry-farmed crops vary more or less from year to year, but in normal seasons and with good cultural methods moderate yields are obtained. They are somewhat larger where summer fallowing is practiced and the crops are rotated. Where irrigation has been developed, and where climatic conditions are favorable, oranges, walnuts, lemons, deciduous fruits, and alfalfa are grown successfully. Sugar beets are grown also to some extent. Commercial fertilizers are used with varying results on the intensive crops, and considerable quantities of organic matter are added to the soil by the growing and turning under of cover crops and by applying stable manure. The soils are well situated and land values are high, higher than for the Yolo sandy loams.

YOLO CLAY LOAMS AND CLAYS.

Description.—The Yolo clay loams and clays group includes the clay loam, the silty clay loam, the clay, and the clay adobe types of the series. Of these the clay loam is by far the most extensive.

The Yolo clay loam consists of a brown, dark-brown, or dark grayish brown, nonmicaceous clay loam, sticky when wet and becoming hard and compact when dry. The type is in most places well supplied with organic matter, and when properly handled is retentive of

moisture. It absorbs water moderately well, except in some of the depressed, heavier textured parts, where the structure has been impaired by puddling. This soil may continue uniform to a depth of 6 feet or more, but in many places at a depth of 12 to 20 inches is underlain by a lighter colored sandy loam to clay subsoil, or by a series of strata of varying textures. It is generally uniform on the alluvial fans and valley slopes, the less homogeneous areas occurring near the streams and in the lower developments. In places the subsoil is distinctly calcareous. It is permeable by roots and water.

The Yolo silty clay loam conforms to the series description, and shows only those variations brought out in the descriptions of the other soils in the group under discussion. Its only difference is that of texture.

The Yolo clay adobe is a brown to dark-brown heavy-textured clay which cracks and breaks down into small aggregates typical of the adobe soils. It is of dense refractory structure, is difficult to cultivate, and clods badly unless handled under favorable moisture conditions. At a depth of about 24 inches the soil is underlain by a lighter colored clay loam to clay subsoil. In places this material is more or less mottled, in this respect resembling the subsoils of the old valley-filling types. It is generally calcareous.

The Yolo clay is composed of a brown to dark-brown clay soil underlain by similar or lighter colored subsoil, which in many places is calcareous. This type is usually very closely associated with the Yolo clay adobe, which it resembles in all essential features except structure, which is slightly less refractory, though showing some of the peculiarities of adobe. The two types merge gradually one into the other. The difference between them is of little agricultural significance.

The soils of the group are rather uniform in character throughout the survey, but a few variations are noteworthy. In the swales and in some of the depressions the soil is heavier and contains more organic matter than elsewhere. Here the color is darker than the average, and the subsoil is calcareous, being much like that of the Chino soils. The soil material also is darker in the zone of contact between this group and the Dublin soils. There are locally a few included gravelly patches, as well as small areas of light textured material which has been washed from higher adjacent alluvial soils and redeposited over the heavier Yolo materials. Such deposits are ordinarily shallow and occur in long narrow belts. In a number of places old valley-filling material occurs below the Yolo material, and near the hills and mountains the soils of the Yolo group are in many places underlain by residual material.

Location.—The soils of this group are largely confined to the central and western parts of the survey. Extensive areas lie along the

streams and slopes of the Puente Hills. Several small though important tracts are mapped east of Los Angeles, south and northwest of Whittier, near Puente, and southwest of Pomona in the San Jose Valley. Other areas occur along Chino Creek east of Puente Hills, and along Coyote Creek south of La Mirada, while many small bodies are developed north and east of Marlboro, south and east of Tustin, and along the upper course of Aliso Creek. An area of silty clay loam occurs in the locality of Corona and other tracts of this type in the San Fernando Valley. Many areas, mostly of clay loam texture, lie west of Los Angeles, in the vicinity of Palms, along Ballona Creek, and in the San Fernando Valley. Areas of clay and clay adobe texture occur mostly in the southwestern part of the survey in the vicinity of Irvine.

Topography and drainage.—The topography of the Yolo clay loams and clays is very similar to that of the Yolo loams. The soils occupy the lower slopes of alluvial fans and portions of flood plains and stream bottoms, which generally have smooth to gently sloping surfaces well adapted to irrigation. Slight undulations may occur in some of the small tracts that have been subjected to erosion, and a few alluvial fan areas are dissected by streamways, but these irregularities do not seriously interfere with cultivation. The relief in most cases affords good drainage, but in some of the flatter parts at the lower levels and parts subject to overflow are poorly drained. In many of these areas high concentrations of alkali salts have taken place.

Utilization and adaptation.—Practically all the soils of the group are utilized for agriculture, the group including some of the more important soils of the survey. Probably more than one-half of the cultivated areas are under irrigation and used in the production of special crops. Where climatic conditions are favorable walnuts, oranges, and lemons are grown and in the areas more subject to frosts deciduous fruits, sugar beets, beans, corn, alfalfa, berries, and truck. Sugar beets are grown on some of the poorly drained areas, and do well where the concentration of alkali is not too great. Where dry farmed good yields of grain and grain hay and beans are obtained when proper care is given to cultivation. Beans are an important crop in the coast region. Water for irrigation is obtained principally from underground sources, but in some instances it is diverted from streams. In most places the expense of irrigation is moderate, though in some of the higher parts where the lift in pumping is excessive the cost is high. Commercial fertilizers and stable and green manures are used in the orange and lemon groves and in a small way in growing walnuts and truck crops. This group of soils is well supplied with roads, and is favorably situated with respect to markets and shipping points.

Dublin Series.

The types included in the Dublin series have dark-gray to black soils, including lighter variations from gray to light brown. The subsoil in many places is similar to the surface soil in texture, but is differently stratified and lacking in uniformity. The surface soil is not ordinarily calcareous, but concentrations of lime sometimes occur in the subsoil. The soils lie on gently sloping alluvial fans, low terraces, and stream flood plains, in places subject to overflow. The surface is usually smooth to slightly uneven and undulating. The soils are moderately well drained, except in some of the flatter parts which are subject to overflow or to a high water table during the wet season. In this survey the series is represented by the Dublin clay loam and clays.

DUBLIN CLAY LOAM AND CLAYS.

The group Dublin clay loam and clays consists mainly of the clay loam, clay, and clay adobe of the series, the last named predominating.

Description.—The Dublin clay loam is a dark-gray or black, heavy to medium textured nonmicaceous clay loam, high in organic matter, but rather compact and retentive of moisture. The subsoil is encountered at varying depths below 12 inches. In color it is lighter, and in texture it may be like the soil, as is the case on the alluvial fans and foot slopes, but in the stream bottoms it varies greatly and may consist of stratified layers of differing textures. It is in many places calcareous, and in the poorly drained areas may be mottled.

When wet the soil is very sticky and upon drying it is inclined to become hard. If tilled when too wet or too dry the fields are plowed with difficulty and are usually cloddy. Nevertheless under good conditions of drainage and culture the structure is moderately friable and favorable to the movement of soil moisture and the development of plants.

The Dublin clay adobe is similar to the Dublin clay loam except in texture and structure. It occupies lower, more poorly drained areas than the clay loam, and is more difficult to till. When cultivated under favorable conditions of moisture it is, however, fairly friable for a soil of its heavy texture.

The Dublin clay, a rather poorly defined and not extensive type, is essentially the same as the Dublin clay adobe, but lacks the pronounced adobe structure of the latter. It is in most cases intimately associated with the clay adobe type, the one passing into the other by imperceptible degrees. At certain seasons an adobe structure is developed, but other times this characteristic is less evident.

Many variations occur in the soils of this group. In places the subsoil has been slightly weathered and modified, until it has some resemblance to that of the coastal plain and old valley-filling soils.

In the valley of San Jose Creek east of Puente the subsoil is strongly calcareous and similar in appearance to the subsoil of the Chino series. The surface soil in the eastern parts of this valley is of somewhat lighter texture than the average, and the areas here include some Dublin loam material. In the San Fernando Valley small tracts of material of loam texture were also included. More or less variation in color occurs in the zone of contact of these soils and those of other series. In a few places a thin veneer of lighter textured recent alluvial material has been deposited over the surface by floods. This is brown in color and consists of Yolo material.

Location.—The Dublin clay loam and clays group occurs mainly in the western and central parts of the survey. Several areas lie northwest and west of San Fernando and east of Pacoima in the San Fernando Valley. These consist mostly of the clay loam but include small tracts of loam. A small area of the clay adobe occurs in the southern part of this valley at the foot of the Santa Monica Mountains. Areas of the clay loam occur between Los Angeles and Santa Monica and Venice, and north of the San Pedro Hills. Other small tracts of the clay adobe lie south of Whittier, northwest of Wanda, southeast of Tustin, and northwest of Gardena and between Los Angeles and Alhambra. The group is most extensive along San Jose Creek where it is represented mainly by the clay adobe type.

Topography and drainage.—The soils of this group occupy valley slopes, gently sloping alluvial fans, nearly level stream bottoms, and basinlike depressions. As a whole the surface is smooth and even. The slope is generally sufficient for moderately good drainage, but in the flat and depressed areas drainage is more or less retarded and poorly developed. The run-off from the slightly higher soils accumulates in these places during the wet season and water may remain on the surface for short periods. Some of the low-lying areas are subject to overflow during floods. Here the water table is generally near the surface and alkali may be present in considerable quantities. Artificial drainage has been provided in some localities with good results.

Utilization and adaptation.—The soils of the group are mainly used for the production of grain, grain hay, beans, and sugar beets. Small tracts with stagnated drainage are not tilled, but are used for pasture. Oranges and lemons have been planted on the more elevated and lighter textured areas in the San Fernando Valley and northwest of Wanda. In the San Jose Valley there are considerable acreages of walnuts, which appear to be making good growth, and in other favorable situations deciduous fruits and truck crops are produced quite successfully. The soil is retentive of moisture, but to insure good yields the fruits and other special crops must be irrigated. The soils are well situated with respect to markets and roads.

WIND-LAID SOILS.

Oakley Series.

The soils of the Oakley series are brown to grayish brown, in places buff in color and are typically uniform in texture and color to the depth of 6 feet or more. However, as occuring in this survey the deeper subsoil and substratum are in many places lighter brown and more compact than the surface soil, and represent a slightly weathered variation approaching in character some of the soils of the Coastal Plain and old valley-filling material. The topography is undulating or rolling with irregular wind-blown ridges and low rounded dune-like hills. The surface material drifts more or less when cleared and supports only a scanty growth of grasses and scattered brush and weeds. Drainage is good. The series is represented in this survey by the Oakley sands.

OAKLEY SANDS.

The Oakley sands group consists of the sand and fine sand of the series.

Description.—The Oakley sand is a brown to light-brown or light grayish brown incoherent, micaceous sand, extending to a depth of 6 feet with little change in texture or other characteristics. The surface soil contains a small amount of organic matter, absorbs water readily, and for a soil of so light a texture is retentive of moisture. Below the surface soil the material is slightly more compact and in places retains its position in vertical cuts.

The Oakley fine sand is similar in all essential features to the Oakley sand except texture, and the two types grade one into the other without distinct lines of demarcation.

Variations in these types include areas containing enough fine material to make the soil more loamy and of better tilth. In the vicinity of Colton small tracts of Hanford material were included, and parts of the group consist of Hanford materials with a covering of Oakley sand. Shallow areas underlain by old valley-filling material situated east of the Mohave River and east of the Whitewater River in the central-eastern part of the survey are mapped with the Oakley, as are also small areas of Dunesand in the region near the coast.

Location.—This group of soils occurs most extensively in the western part of the survey along the coast between the San Pedro Hills and Playa del Rey. Two areas occur west and northwest of Colton and others are situated on the desert east of the Mohave River, in Johnson Valley, and near Coachella Valley, about 1 mile north of Whitewater.

Topography and drainage.—The Oakley soils have an undulating topography resulting from their wind-laid origin. Rounded knolls, low parallel ridges, and slight depressions are frequent, and the sur-

face which in general is smooth has been more or less modified by the drifting of the materials which are unstable if disturbed in cultivation. Windbreaks have been planted in several places to prevent this. The drainage is good and there is very little run-off.

Utilization and adaptation.—The greater part of the group remains in its native state with a sparse cover of brush and annuals. In this condition it is used for pasture. Near the coast a part is utilized in a small way for the production of grain, grain hay, beans, and corn. On account of the sandy nature of the soil and the scarcity of water, irrigation is not practiced on these coast areas, but low to moderate yields are obtained without it. Little fertilizer is applied, and only moderate amounts of barnyard manure. In some places the topography is favorable to some citrus fruits; alfalfa, and truck crops are grown with irrigation, but the acreage is small. The types as a whole are of little importance.

MISCELLANEOUS MATERIAL.

ROUGH BROKEN AND STONY LAND.

This group Rough broken and stony land material includes the types Rough broken land and Rough stony land as these have been recognized in previous surveys. Both these are mainly non-agricultural, but some small areas of arable soils, usually of but a few acres each, are included. Some of the larger of these included areas would in a more detailed survey be differentiated and shown under the proper series and type classification. The soil material represents a variety of residual and old valley-filling soils, mainly of the Holland, Sierra, Altmont, Diablo, Placentia, and Ramona series.

Rough broken and stony land, covering as it does the mountainous parts of the area, forms a much greater extent of country than any other of the types or groups of soils mapped in this survey. A large part of it is embraced within the national forests. These areas with others under private ownership are utilized under certain restrictions and in part for grazing of cattle and sheep which constitutes the chief agricultural use.

COASTAL BEACH AND DUNESAND.

Description.—Costal beach and Dunesand consist of a light-brown to gray medium textured loose incoherent sand six feet or more deep. The soil is very poor in organic matter, and has a low water-holding capacity. The group, as its name indicates, consists of two main types having similar soil material but quite distinct in their manner of accumulation and topography. The Costal beach portion forms the water front along the ocean and occurs as a gently sloping or shelving belt less than one-fourth mile wide, and is subjected to more or less periodic inundation from the ocean during high tides and

stormy periods. The included Dunesand part consists of areas of undulating, rolling, or rather rough dune topography lying typically adjacent to the beaches. The dunes have been formed by the accumulation of sand blown inland from the beach deposits. Like the beach areas the dune areas are for the most part very narrow and generally barren of vegetation. The Dunesand is still subject to more or less movement by the wind.

The groups in this survey include several inextensive tracts of "made land," formed by filling in depressed or submerged areas to fit for use as building sites. The material used has been dredged from channels and harbors, and contains small amounts of silt or clay and numerous shell fragments, but as a whole is very much like that of the beaches. The surface is rather undulating and subject to modification by the wind. The deposits vary in depth from one to six feet or more.

Location.—The principal areas of Costal beach and Dunesand occur along the ocean from Santa Monica to Redondo, from San Pedro to Long Beach, and from Alamitos Bay to Newport Bay.

Utilization and adaption.—The land is nonagricultural in character and supports very little vegetation. In a few places where the surface is protected from winds, and where the soil contains more fine material than typical a little truck is grown.

RIVERWASH

Description.—Riverwash consists of coarse to fine sands, gravelly sand, and coarse rounded cobbles and boulders, the character of the deposits varying with location and character of the streams by which they are transported and laid down. At the mouths of mountain canyons the material includes many large boulders, some attaining a diameter of several feet. Here more or less coarse gravelly alluvium fills the interstices between the stones but only a small percentage of fine sand or silt is present. As the streams descend in their course through the valleys their fall decreases, the stone and coarse gravel content gradually diminishes and the deposits consist principally of finer sandy material. Near the coast region the channels become filled, until they become higher then the adjacent soils, when the streams are forced into new channels. The old abandoned courses gradually grow up with willows and vines, and during floods fine sandy or silty material is deposited over the surface. In such places some small areas are used in growing truck crops, but as a whole the type is practically worthless for agriculture.

Location.—Riverwash occurs in the channels of practically all of the streams but in many places the strips are so narrow and so closely associated with other material that they could not be outlined on the map.

TIDAL MARSH.

Description.—Tidal marsh consists of materials varying in texture from sand to clay, distributed by tidal currents and laid down in the marshy areas along the ocean. The soil is brown or dark grayish brown to gray. It is more sandy near the ocean than farther inland where the deposits are made in brackish waters. The subsoil or underlying material is also subject to variation in texture and is in many places composed of alternating strata of light and heavy material, and mottled, containing calcareous nodules and partially decomposed fragments of plants.

Location.—Tidal marsh is developed in a few areas along the coast, mainly at the mouths of rivers. Important developments occur between Playa del Rey and Venice and between Long Beach and Wilmington. Other comparatively large areas, some of them several square miles in extent, are situated in the locality of Alamitos Bay and southeast along the coast to Newport Bay.

Topography and drainage.—The topography is flat and depressed and drainage poor. Many sloughs and estuaries traverse the type, and the greater part of it is inundated by each succeeding high tide, which keeps the soil in a water-logged condition. Over most of the areas salts have accumulated in quantities sufficient to prevent the growth of any cultivated crops.

Utilization and adaptation.—Tidal marsh supports a growth of salt-resistant plants. Its natural condition is of no value for agriculture. In a few places some reclamation work has been attempted. Levees have been built, tide gates installed, and in some instances flooding with fresh water to remove the excess salt. In other places the areas have been filled in. Such reclamation ordinarily has been carried on in the vicinity of the seaside resorts, and in most instances the land is used for building sites rather than for agriculture.

IRRIGATION.

The low precipitation of southern California and the fact that the greater part of the rain falls during the winter months makes irrigation an important factor in crop production. In most instances the agricultural progress of the various localities now highly developed has been brought about through the extension of irrigation, which has made practicable the production of oranges, lemons, and walnuts, instead of the less profitable dry-farmed grain and grain hay formerly the leading crops of the region. As a whole the water supply is inadequate, making it impossible to provide means of irrigation for the entire region. In the sections where irrigation is practiced economy in the use of water has become a necessity, and the tendency has been to extend the distributing systems and the irrigated acreages and to diminish the quantity of water used per acre.

The early Missions recognized the value of irrigation and practiced it crudely in a small way. About 1820 to 1830 the San Bernardino Branch Mission constructed the Mill Creek "zanja," which was one of the first ditches built in southern California.[7] As early as 1835 water was diverted from the Santa Ana River to the lands west of the Santa Ana Canyon. The Mormons began settlement in the San Bernardino Valley in the early fifties, and they placed a considerable acreage under irrigation in this locality. Between 1870 and 1890 development of irrigation enterprises in various parts was active. The Highlands region received water by 1874 and the upper and lower Riverside canals were completed in 1876. The Gage Canal supplied by pumps, was completed in 1888, and furnished water to the high mesa lands in the vicinity of Riverside. Since 1880 many pumping plants have been installed, and large acreages have been irrigated with water pumped from underground sources as well as from artesian wells. According to the United States Census, in Los Angeles, Riverside, Orange, and San Bernardino counties, parts of which are included within the survey, there were 11,521 irrigated farms, with a total area of 342,356 acres under irrigation. Of this amount 146,565 acres were irrigated by gravity systems. Data compiled by the Office of Experiment Stations in 1912 [8] gives the following areas irrigated in the various geographical districts within the survey: In the San Gabriel Valley 36,536 acres; in the Los Angeles Coastal Plains region, 117,507 acres; in the valley of San Jose Creek, 3,401 acres; in the Pomona Valley and Cucamonga Plain, 44,823 acres; in the San Bernardino Valley and Riverside region, which includes the Rialto, Bloomington, Colton, and Redlands districts, 79,992 acres; in the Yucaipe Valley, 2,500 acres; in the San Jacinto Valley 23,112 acres; in the vicinity of Corona, 6,750 acres; and in the San Gorgonio Pass, tributary to Beaumont and Banning, 5,330 acres.

The principal sources of water supply within the survey consist of the Los Angeles River, the San Gabriel River, the Santa Ana River, various smaller streams in the San Gabriel, San Bernardino, and San Jacinto Mountains, and the underground sources of supply.

The entire flow of the Los Angeles River during the summer months is diverted several miles above Los Angeles for municipal purposes. The annual flow of the stream is variable, and during the winter the stream sometimes carries large volumes of flood waters.

The San Gabriel is one of the important streams of the survey. The entire surface flow is utilized for irrigation in the San Gabriel

[7] This and much of the subsequent data given in this chapter is taken from the "The Hydrology of San Bernardino Valley, Calif.," W. C. Mendenhall, U. S. Geological Survey Water Supply and Irrigation Paper No. 142.

[8] Irrigation Resources of California and their Utilization, Frank Adams, Bul. 254, Office of Experiment Stations, U. S. Department of Agriculture.

valley. Much of the surface flow of this stream during the dry season sinks into the sands and gravels of the alluvial fan below the canyon mouth and continues as underflow, but a portion of this is recovered and utilized by pumping. In the vicinity of the "Narrows" near Whittier, where the stream enters the Coastal Plains region, some of the underflow comes to the surface and this, with large additional quantities delivered by pumping from wells, is diverted through canals and utilized in the Coastal Plain belt. The San Gabriel is reported to have a drainage area of 700 square miles, one-third of which, consisting of mountain slopes, contributes most of the run-off.

The Santa Ana River furnishes important water supplies for power, irrigation, and municipal use. The surface supply is utilized largely in the vicinity of Redlands and Highlands. Further supplies recovered by pumping from the underflow are utilized about San Bernardino and Riverside. Below Riverside the underflow is brought to the surface by bedrock and again diverted for power and irrigation purposes about Corona. Below this further amounts are diverted and recovered by pumping and utilized for irrigation in the vicinities of Santa Ana and Anaheim, and in the adjacent Coastal Plains region. This stream has a drainage basin of 1,800 to 1,900 square miles, about one-third of this lying in the mountains. An important feature in the conservation and utilization of the waters of this stream consists of the Bear Valley Dam, which impounds tributary waters. Completed in 1884 and replaced and enlarged in 1911 it forms a reservoir with a capacity of 65,000 acre-feet. This is reported to have added 7,500 acres to the irrigated citrus lands of the valley.

Another important storage reservoir is the Hemet Reservoir on the San Jacinto River in the Hemet Valley, formed by a dam 125 feet high and having a storage capacity of 8,000 acre-feet.

In the San Fernando Valley extensive areas have recently been placed under irrigation by water supplied by the Los Angeles city aqueduct, through which water is conveyed for irrigation and municipal purposes from the Owens River, lying on the east side of the Sierra Nevada and far north of the area surveyed. Irrigation of lands in this valley from this source is being extended with consequent rapid agricultural development. A large part of the land under this system lies in the more western part of the valley and outside the limits of this survey.

In the Mohave Desert region a number of scattered tracts of small extent are irrigated, mainly by pumping from an underground source. Other small areas of local importance are irrigated by gravity systems. taking water from the Mohave River. At the Box S Ranch and in the vicinity numbers of wells have been drilled. Some of these are flowing and some irrigation is carried on here. In the Lucerne and Apple Valleys, lying, respectively, to the east and west, water from

similar sources is used. Springs of small flow occur in the desert. Among these the best known are the Rabbit Springs, Box Springs, Cushenbury Springs, and Old Woman Springs. At Means Wells, in the extreme northeastern part of the survey, a well has been dug to the depth of 26 feet, the water rising to within 12 feet of the surface. Various plans for irrigation of extensive tracts in the Mohave Desert, from gravity waters impounded in reservoirs in the San Bernardino Mountains, have been considered, but no extensive development has as yet taken place. Projects are now under consideration, and companies are organizing, and it is hoped further development of alfalfa and fruit lands in this part of the survey can be realized.

In the distribution and application of water unusually economical and efficient methods have been developed. Distributing systems are mainly by concrete or cement lined canals or by pipes laid underground. Alfalfa is irrigated largely by the use of movable slip-joint galvanized-iron pipe, and in the irrigation of the intensively cultivated fruits and other special crops various forms of basin or check and furrow methods of application are employed.

The duty of water varies with the character of soil, crop grown, and locality. In the San Gabriel Valley in the irrigation of citrus fruits, it is reported, in the publications previously referred to, as 7 to 8 acres per miner's inch flowing continuously. The same amount of water is stated to be capable of irrigating 10 acres of deciduous fruits, or 3 acres of alfalfa. In the Coastal Plains region alfalfa is irrigated five times, and 1 miner's inch for 250 days serves about 3 acres. In the irrigation of fruit and berries this amount of water is sufficient to irrigate about 7½ acres. In the San Bernardino Valley the duty of water is rated as from 2 to 4 acre-feet per year for irrigation of alfalfa and truck crops. In the Beaumont region 1 miner's inch is allotted to about 10 acres, while at Banning this amount serves 6 to 7 acres.

During recent years development and extension of irrigation projects in the intensively cultivated valleys has been slow, on account of the earlier appropriation of the entire available water supply, but some of the irrigated parts of the survey are capable of still further extension, with increased efficiency and economy in the use and distribution of water.

Irrigation from artesian wells is of importance in parts of the survey, the principal artesian districts lying southwest of Chino, south of Santa Ana, southeast of Ramona, in the southwestern part of the survey along the coast and in the vicinities of San Bernardino and San Jacinto.

DRAINAGE AND ALKALI.

In the area included within this survey the soils of residual origin and those derived from the older unconsolidated valley-filling de-

posits are characterized by well-developed to excessive drainage, under which condition alkali is not likely to accumulate. Thus residual soils of the survey are practically without concentrations of salts in injurious quantities, and the soils derived from valley-filling and Coastal Plain deposits carry an excess of soluble salts in only a few places. The recent alluvial soils, however, occupy in part lower lying positions in areas of poorly developed regional drainage, and it is with these that accumulation of alkali salts in injurious quantities is commonly associated. Some of these alkali areas lie along the coast, where the rainfall is sufficient to leach out the salts, were natural drainage conditions better developed. In some of the parts of the survey of lowest rainfall, as in the Coachella Valley, constituting a part of the Great Colorado Desert, and in other desert valleys, the soils are of porous structure, good slope, and owing to favorable natural drainage are free from injurious concentrations of salts.

The localities in which alkali accumulations occur may be considered in three divisions, those of the coastal districts, of the interior valleys, and of the desert region.

The principal alkali areas are indicated upon the accompanying soil map by symbols inclosed within solid red lines. In the parts of the present survey covered by included earlier detailed soil surveys the data was taken from the maps of the earlier work and is based upon field determinations of the average amount of total soluble salts present in the air dry soil to the depth of 6 feet. In the present reconnoissance survey however, no attempt was made to indicate the various grades of concentration of the salts, and in the portions of the survey not previously covered by detailed surveys the alkali areas indicated are less accurately drawn and are based upon evident superficial indications.

Coastal districts.—The most extensive and important areas of alkali accumulation occur in the coastal districts. The affected areas lie in the comparatively flat and lower lying delta plains and associated drainage basins, or in the Tidal marsh lands near the coast.

In the former the accumulation of soluble salts is associated with a high water table, and are due to long continued evaporation of large quantities of water containing small amounts of dissolved salts. In the latter the salts are derived from sea water.

The principal area of accumulation in the coastal district covers the lower part of the Santa Ana, San Gabriel, and Los Angeles River deltas and extends irregularly along the coast from Newport Bay northwesterly to the vicinity of Wilmington. It covers a belt having a maximum width of about 12 miles, except in the vicinities of Fairview and Long Beach, where it is interrupted by areas of well-drained higher lying soils of good drainage. In the vicinity of

Compton the belt narrows to a width of one-half to 3 miles and extends along a shallow basinlike depression to the vicinity of Culver City, about midway between Los Angeles and Santa Monica. A smaller area of alkali concentration comprises the Tidal marsh and adjacent low-lying land between Santa Monica and Playa del Rey and extending inland a distance of about 4 miles. There are also small isolated areas affected by slight concentrations of salts, occupying local depressions on the upper parts of the alluvial fans, and lying in stream bottoms where they are subject to seepage from higher lying lands.

The concentration of salts in the areas indicated is variable, ranging from that sufficient to affect only the more sensitive crops or appearing only in scattered local spots, to extensive uniform concentrations sufficient to render the land in its present condition incapable of supporting cultivated crops. These conditions are indicated and are described in greater detail in the reports of the previous detailed soil surveys.[9]

In the soils of light texture with porous subsoils and having a high water table, the salts are concentrated mainly in the surface material. In those having heavier subsoils the salts are likely to be more uniformly distributed through the soil profile, or they may be more or less segregated in the subsoil. Most of the alkali-affected areas consist of the soils of the Hanford, Chino, and the Tujunga series, principally those of the first two mentioned. Small areas of the older valley-filling soils of the Ramona and the Montezuma series are affected but these are relatively unimportant and the maximum salt content normally occurs in the subsoil. The areas of Tidal marsh are generally heavily impregnated and covered by alluvial deposits where the material retains the salts for a long time.

The character of the salts varies with the locality, their origin, and agencies active in their accumulation. In the Tidal marsh lands and adjacent areas near the coast, sodium chloride or common salt predominates. Further inland sodium sulphate predominates. Sodium carbonate or "black alkali," a highly injurious salt, is conspicuous only in a few areas of small extent and is confined mainly to the surface foot of soil.

Much of the alkali land in the coastal region was originally swampy and mainly nonagricultural, but considerable areas have been reclaimed or improved by artificial drainage. Excepting the areas of Tidal marsh and adjacent areas of very poor drainage and heavy texture and structure, there are but few areas not now utilized for crops. Sugar beets are the most important crop on the alkali lands.

[9] See Soil Survey of the Los Angeles Area, Calif., and soil Survey of the Anaheim Area, Calif., Field Operations, Bureau of Soils, 1916.

Profitable yields are obtained, except in the areas of heavy concentration and shallow water table. Beans are grown to some extent in areas of slight accumulation, and alfalfa is grown successfully where the salt concentrations are low to moderate and the water table can be maintained at a depth of several feet. Grain and grain hay are quite extensively grown, frequently in rotation with sugar beets. Orchard fruits and the more sensitive small fruits and field crops can not be grown successfully under present conditions, where the salts occur in more than slight concentrations. The most of these low-lying soils are, however, unsuited to fruit production on account of adverse climatic conditions and high water table.

In the coastal district a gradual extension of agriculture on the alkali lands seems to be taking place. This is being made possible by the improving drainage conditions, adoption of better methods of culture and the planting of more resistant crops. The areas of Tidal marsh and adjacent bodies of heavy soils are, however, utilized mainly for pasture. Reclamation here includes not only means of drainage, but protection from overflow and the flooding of the land with fresh water to leach out the salts.

The interior valleys.—The areas of alkali accumulation in the interior valleys occur mainly in shallow basins where obstructed flow of underground or surface waters have resulted in a high water table, or in areas of slight fall traversed by débris choked and poorly defined streams.

There is a relatively small but noticeable area of accumulation in the vicinity of Chino. Two areas are indicated on the map in this section, the larger covering an area of 2 square miles. The accumulation of alkali here is not large and is indicated in the field mainly by small spots of impaired productiveness with intervening areas in which but little apparent injury has occurred.[10] The affected areas are confined mainly to the soils of the Chino series. Natural conditions leading to the accumulation of the salts have been changed by laying drains and the improved soils are now utilized for the production of sugar beets.

Other small areas of accumulation occur south of El Monte and north of Bartolo Station on the Los Angeles and Salt Lake Railroad, and in the valley of the Santa Clara River in the northwestern part of the survey. The subsoils in these areas are coarse and porous and a shallow water table occurs. The salts are mainly in the immediate surface soil, and will probably not become highly concentrated, and can be readily removed by drainage and irrigation. Owing to their small extent only a part of these areas are shown on the map. Other areas shown by spotted field conditions occur south of Ontario

[10] See Soil Survey of the Pasadena Area, Calif., Field Operations of the Bureau of Soils, 1915.

in the soils of the Chino and the Antioch series.[11] These, also, are not indicated upon the map. They have been materially improved by artificial drainage, are utilized mainly for sugar beet culture, and are similar to the areas noted in the vicinity of Chino. Other areas of alkali concentration in the region covered by the detailed Riverside survey occur north and west of Arlington and east and southeast of San Bernardino. The water table in these bodies occurs at a shallow depth. Here the steps taken to reclaim the land have been less effective, the salts occur in somewhat greater concentrations, and utilization of the lands for crops is seriously threatened or impaired. The salts are confined mainly to the surface foot of soil, in which as much as 1 per cent or 1,000 parts of salts per 100,000 of air dry soil is sometimes present. The concentration of the salts in the surface renders the conditions particularly unfavorable. The highly injurious black alkali is also present in some of these localities. In most of them, however, the excess salts can be removed by drainage and flooding.

A number of other areas of alkali land occur in the southeastern part of the survey where they occupy local flats and drainage basins. The larger of these occupies a belt varying in width from about one-half to 2 miles and extending from the vicinity of San Jacinto in a northwesterly direction for a distance of about 7 miles, where it forms an elbow and swings to the southwest to the vicinity of Perris. This belt of alkali soils occupies the low flat basin which forms the sink of the San Jacinto River, and in which during most of the time the flow of this stream sinks below the surface. A large proportion of this area is subject to overflow during flood periods, and over the most of it the water table occurs at shallow depths. The soils are mainly those of the Hanford, Chino, and the Las Flores series. In parts of this belt the total salts to a depth of 6 feet is not great and the greater part is accumulated in the surface, while in other places the content appears to be high and less localized in the profile. The area is utilized mainly for pasture, but at the present time work is under way to rid the soil of excess water, and when this is done alkali conditions will probably be improved. Most of this area, it is believed can be reclaimed and utilized for cultivated crops.

Other areas of local accumulation occur in the vicinity of Elsinore, southeast of Murrieta, in the Menifee Valley, and extending as a narrow belt east and northeast to the San Jacinto Valley, in the Domenigoni Valley, and in Diamond Valley. Other areas occupy the flat, poorly drained parts of the Coahuila and Terwilliger Valleys in the extreme southeastern part of the survey. These areas are associated with low-lying, poorly drained areas of soils of the Hanford, Foster,

[11] See Soil Survey of the Riverside Area, Calif., Field Operations of the Bureau of Soils, 1915.

Ramona, and the Las Flores series. The salt content appears to be variable and is probably not great or at least is localized in the surface, but detailed field tests were not made to determine this definitely. In some of these localities drainage outlets could not be easily obtained, but in a number of the areas reclamation apparently presents no great difficulty.

The desert region.—While most of the soils of the desert region are of good slope and well drained, there are some areas of alkali accumulation shown on the map. These, which represent small flat desert drainage basins, cover in all several square miles. They are distributed in the eastern part of the Mohave Desert section of the survey from Deadman Point eastward, the soils affected belonging to the Lahontan series. A similar area lies in a small poorly drained basin extending southeast from Baldwin Lake and occupied by soils of the Foster series. The lower parts of these drainage basins or flats are occupied by intermittent lakes or playas of flat barren surface receiving flood waters from adjacent alluvial fan slopes. During the rainy season or for a short period following occasional local storms they are covered with a shallow sheet of muddy water which is removed by evaporation, leaving a deposit of silt and clay with impregnating salts on the surface.

The playas are not farmed and as they are without outlet and are occupied by heavy soils of poor physical characteristics their reclamation is not feasible. The adjacent lower desert slopes, however, over which the alkali accumulations extend for some distance, have some agricultural possibilities and in a few instances the alkali accumulations occur in lands now being farmed and are causing some trouble. These slopes can in most cases be drained to the lower "playas" or sinks and the excess salt leached from the soils by surface flooding where water is available for this purpose.

The alkali areas in this part of the survey are shown only approximately on the map and detailed examinations would probably bring to light other affected areas. On the other hand, some of the areas sketched may be slightly exaggerated. Owing to the limited agricultural development in this region and to the fact that the areas of alkali are confined mainly to the playas which are subject to periodical overflow and are unutilized, the alkali problem has not become critical.

SUMMARY.

The area embraced within this survey includes parts of Orange, Los Angeles, San Bernardino, and Riverside Counties. It has an extent from north to south of about 70 miles and from east to west of 115 miles, and embraces 3 main regions, the mountain region, the desert region, and the valley region, differing in topography, climate, and other natural features.

The mountain region covers about one-half the area, consists of rough dissected country, sparsely settled and mainly nonagricultural.

The desert region embraces a part of the Mohave Desert in the northeastern, and a part of the Coachella Desert in the southeastern parts of the survey. It consists predominantly of alluvial fan-formed plains with included drainage basins or playas, and some isolated or bordering barren and rocky mountain ridges and knobs. Agricultural development is confined to a few small areas.

The valley region embraces the Great Valley of southern California. This consists of a number of related structural valleys which have become the seat of most of the agricultural and industrial development of southern California. With these are included some low-lying hill and mountain areas which are settled to some extent and partly utilized for agriculture. A large proportion of the population is in incorporated cities and towns but many thickly settled rural districts occur.

Los Angeles is the principal city of the area and is connected with a large number of other important cities and rural communities by excellent systems of highways and steam and electric railway lines.

The climate is characterized by a wet and a dry season corresponding to winter and summer. Rainfall and temperature vary widely, owing to the extent of the area and to diversity in topographic and other modifying features. The rainfall ranges from less than 5 to more than 30 inches in different parts of the survey. Temperatures are mild and uniform along the coast, but summer temperatures in the desert and inland valleys are frequently high, and in the winters they may approach or fall below zero in the Mohave Desert. Frostless belts occur in the principal coastal and inland valleys. Fogs are frequent along the coast. Thunder and hail storms are rare, except in the mountain and desert regions.

The first settlement took place with the founding of the early Missions by the Franciscans, beginning about 1769. This was followed by the granting of large tracts of land by the Spanish and Mexican Governments to individuals who utilized the land for the raising of cattle and sheep. Later the growing of grain became extensive, and this is still the principal industry on unirrigated lands. Development of irrigation has led to extensive cultivation of citrus and deciduous fruits, grapes, olives, small fruits, walnuts, truck crops and sugar beets. The growing of beans and alfalfa, and dairying, poultry and bee culture are also of importance. Most of these products are produced under methods of intensive cultivation, and many of them in small individual tracts.

The survey shows a large number of soil types and soil series, varying in topography, origin, and mode of formation. They are

embraced in five main groups, viz: Residual soils, soils derived from Coastal Plain and old valley-filling material; recent alluvial soils, soils derived from wind-laid material, and miscellaneous materials mainly nonagricultural.

The residual soils are derived by weathering in place of consolidated rocks. Most of the higher mountain ranges are of granitic formation and are of rough topography and the soils are for the most part stony and shallow and classed as miscellaneous material. The arable soils of this region are of small extent. They are classed in the Sierra and the Holland series, the former being predominantly of red, the latter of brown color.

Most of the lower ranges of mountains and hills adjacent to the coast or associated with the valleys are composed of sedimentary rocks, consisting of shales, sandstones, and conglomerates. These give rise to soils of the Altamont and Diablo series. The former are brown, for the most part well drained, and in some cases calcareous. The topography is sometimes steep but the surface is largely smooth. The types are extensive. They are utilized mainly for pasture and in the production of grain and hay without irrigation. The Diablo soils are of similar origin, but being higher in organic matter they are darker in color. They are generally calcareous, but in topography and utilization they are similar to the Altamont soils.

The soils of the Coastal Plain and old valley-filling material are derived through weathering from old stream laid or marine deposits. They occupy remnants of old alluvial fans, alluvial plains, or stream or marine terraces now undergoing erosion. They are generally well drained and are characterized by heavy or compact subsoils, by hardpan or by concentration of lime or other deposits in the underlying material. They are extensive and widely developed and include many important types of soil. The soils fall in the San Joaquin, Placentia, Ramona, Pleasanton, Madera, Antioch, Las Flores, Montezuma, Mohave, Hesperia, and Lahontan series. Of these the Placentia and Ramona are derived mainly from granitic rocks, the former being of red, the latter of brown color. They embrace important citrus fruit soils. The San Joaquin series are of red to reddish-brown color and have a red or brown hardpan. They are utilized mainly for dry-farmed grains. The Montezuma soils are of dark color and have calcareous subsoils. Soils of this series are devoted mainly to the production of grains, citrus fruits, beans, and truck crops. The Mohave and Hesperia series embrace desert types of wide extent but not yet widely utilized. The others are of minor extent and importance.

The recent alluvial soils consist of stream laid deposits occupying the flood plains and lower terraces along streams and the sloping to relatively flat alluvial fans and delta plains, the last two forming the

greater proportion of the lands. The soils are prevailingly deep, friable, fertile, and easily irrigated, and are of extensive occurrence. They include a large number of soils that are intensively cultivated. The crop range is wide.

The recent alluvial soils classified in the Tujunga, Hanford, Foster, Chino, and Cajon series are composed mainly of granitic materials. The Tujunga soils, which are of light color, are utilized mainly for the production of truck crops, deciduous fruits, and grapes. The Hanford soils, a brown series, are devoted to citrus and deciduous fruits, beans, truck crops, sugar beets, and olives. This is one of the most widespread and important series in the survey and is utilized for nearly every crop grown in the general region. The Foster series, which is not extensive, is of darker color and is less well drained than the Hanford and of relatively little importance. The Chino soils are of dark color and have calcareous subsoils. They occupy areas of reletively poor drainage, and in many places contain alkali, but are important sugar beet soils. The Cajon series is similar to the Hanford series, but occurring under desert conditions is calcareous.

It is of little agricultural importance at present owing to adverse climatic conditions.

The soils of the Yolo and the Dublin series are recent alluvial soils derived mainly from materials coming originally from sedimentary rocks. The Yolo soils are brown. They are not as extensive as the Hanford soils but are productive and are utilized extensively in the growing of beans and fruit, truck, and general farm crops. The Dublin soils are dark in color and in many places calcareous. They are not as well drained as the Yolo soils and are utilized mainly for grain and grain hay, sugar beets, and beans, and in favorable situations for fruits.

The soils derived from wind-laid material are classified in the Oakley series. They are brown to light brown in color, of small extent, and comparatively unimportant. They are used to some extent in the production of grain and truck crops.

The types of miscellaneous material, including Rough broken and stony land, Riverwash, Coastal beach and Dunesand, and Tidal marsh are of little importance in the agriculture of the area, though together they occupy a large part of the area covered by the survey.

Irrigation, which was introduced by the Mission Fathers and later developed and extended by early Mormon and succeeding settlers, has reached a high state of development. It has been the controlling factor in the development of the intensive agriculture dominating the principal valleys of the survey. Water for this purpose is diverted by gravity from the principal streams, the supply

being augmented in some cases by storage reservoirs; or is obtained by pumping from underground sources; and from artesian wells. The supplies of gravity and of much of the underground waters, are quite fully utilized and are effectively and economically distributed. In certain localities, however, the irrigated area is capable of extension by storage and by further development of underground sources of water.

Most of the area is well drained and free from alkali, but localities of poorly developed drainage and alkali accumulation occur. The larger of these are in the low flat parts of the delta plain of the larger streams near the coast. Smaller areas occur near Chino, Ontario, Arlington, San Bernardino, in the valleys in the southern part of the survey, and in the Mohave Desert. Most of these are utilized for grazing or for the production of sugar beets and other more resistant crops. Marked improvement of these areas has been brought about in many cases by artificial drainage, and reclamation of these lands is capable of further extension.

○

[PUBLIC RESOLUTION—NO. 9.]

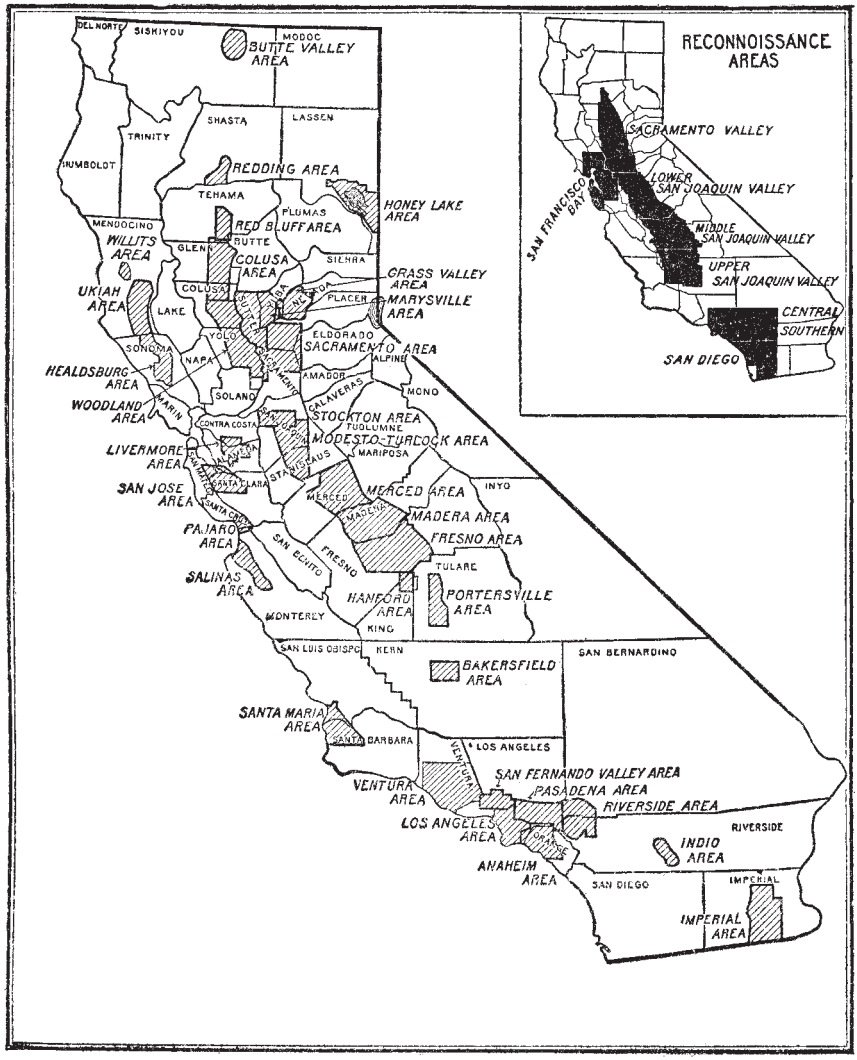
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]



Areas surveyed in California.

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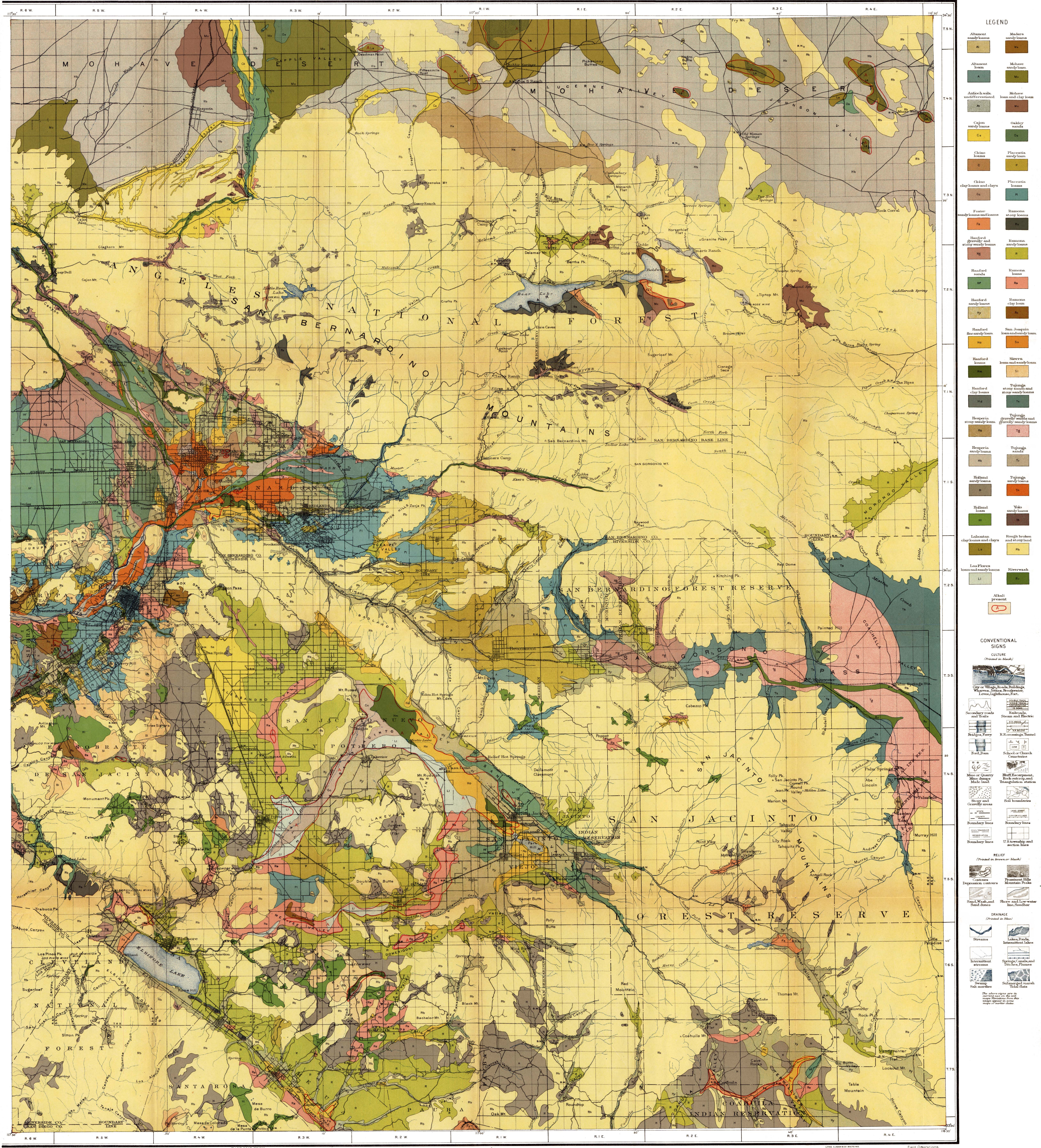
U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
CALIFORNIA
RECONNOISSANCE SURVEY - CENTRAL SOUTHERN AREA - EASTERN SHEET

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
THOMAS F. HUNT, DIRECTOR
CHARLES F. SHAW, IN CHARGE SOIL SURVEY



Macy H. Lapham, Inspector, Western Division.
Soils surveyed by J. E. Dunn, in charge, and
L. C. Holmes, A. T. Strahorn of the
U.S. Department of Agriculture and
J. E. Guernsey of the University of California.

BASE MAP FROM
U.S. GEOLOGICAL SURVEY SHEETS
INDEX ON WESTERN SHEET

Scale 1:125000

LITHO. A. HOEN & CO. BALTO. MD.

Field Operations
Bureau of Soils
1917.

U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
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SOIL MAP
CALIFORNIA
RECONNOISSANCE SURVEY - CENTRAL, SOUTHERN AREA - WESTERN SHEET

UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION
THOMAS F. HUNT, DIRECTOR
CHARLES F. SHAW, IN CHARGE SOIL SURVEY

LEGEND

- Altamont sandy loams — Al
- Altamont loam — A
- Altamont clay loam and clays — Ac
- Antioch soils, undifferentiated — At
- Cajon sandy loams — Ca
- Chino loams — C
- Chino clay loams and clays — Cc
- Diablo clay loams and clays — Dc
- Dublin clay loam and clays — Dl
- Hanford gravelly and stony sandy loams — Hg
- Hanford sands — Hf
- Hanford sandy loams — Hy
- Hanford fine sandy loam — Ho
- Hanford loams — Hm
- Hanford clay loams — Hd
- Hesperia stony sandy loam — Hs
- Hesperia sandy loams — Hb
- Holland sandy loams — H
- Holland loam — Hl
- Coastal beach and Dunesand — Cd
- Riverwash — Rv
- Madera sandy loams — Ms
- Mohave loam and clay loam — MC
- Montezuma adobe soils — M
- Oakley sands — Os
- Placentia sandy loam — P
- Placentia loams — Pl
- Pleasanton loam — Po
- Muckyphase — Pc
- Ramona stony loams — Rs
- Ramona sandy loams — R
- Ramona loams — Ra
- Ramona clay loam — Rc
- San Joaquin loam and sandy loam — Ss
- Sierra loam and sandy loam — Sl
- Tujunga stony sands and stony sandy loams — Ts
- Tujunga gravelly sands and gravelly sandy loams — Tg
- Tujunga sands — Tu
- Tujunga sandy loams — Tn
- Yolo sandy loams — Ys
- Yolo loams — Y
- Yolo clay loams and clays — Yc
- Rough broken and stony land — Rb
- Tidal marsh — T

Alkali present — A

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort.

Secondary roads and Trails

Railroads: Double track, Single track, Under construction, In use, Abandoned, Steam and Electric

Bridges, Ferry

R. R. crossings, Tunnel

Ford, Dam

School or Church, Cemeteries

Mine or Quarry, Mine dumps, Made land

Bluff, Escarpment, Rock outcrop, and Triangulation station

Stony and Gravelly areas

Soil boundaries

Boundary lines: State, County, Land grant, City or village, City, township, Reservation

U.S. Township and section lines

RELIEF
(Printed in brown or black)

Contours, Depression contours

Prominent Hills, Mountain Peaks

Sand, Wash, and Sand dunes

Shore and low water line, Sandbar

DRAINAGE
(Printed in blue)

Streams

Lakes, Ponds, Intermittent lakes

Intermittent streams

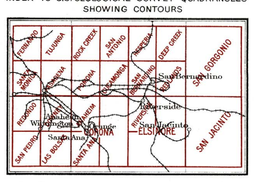
Swamp, Canals, and Ditches, Flumes

Swamp, Salt marshes

Submerged marsh, Tidal flats

The adverse signs are in current use on the soil maps. Variations from this usage appear in some maps of earlier date.

INDEX TO U.S. GEOLOGICAL SURVEY QUADRANGLES SHOWING CONTOURS



Macy H. Lapham, Inspector, Western Division.
Soils surveyed by J.E. Dunn, in charge, and L.C. Holmes, A.T. Strahorn of the U.S. Department of Agriculture and J.E. Guernsey of the University of California.

BASE MAP FROM U.S. GEOLOGICAL SURVEY SHEETS

Scale 125000
1 0 1 2 3 4 5 Miles
1 0 1 2 3 4 5 Kilometers

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